Roads Scholar I

Proper Signs and Markings
Participant Manual

The mission of the West Virginia LTAP Center is to foster a safe and efficient transportation system which enhances the economic development of West Virginia by improving skills and increasing knowledge of the transportation workforce and decision makers.

Presented by:
West Virginia Local Technical Assistance Program

653 B Engineering Sciences Building
PO Box 6103
Morgantown, WV 26506-6103
304-293-3031 ext 2612 or 2629
Fax: 304-293-7109
http://wvltap.wvu.edu

A Closer Look at the WV LTAP

The WV LTAP is part of the national Local Technical Assistance Program (LTAP) and Tribal Technical Assistance Program (TTAP), which is composed of a network of 58 Centers – one in every state, Puerto Rico and regional Centers serving tribal governments. The Federal Highway Administration (FHWA) created the LTAP in 1982 to provide local agencies with information and training programs to address the maintenance of local roadways and bridges.

The WV LTAP receives funding from the FHWA and the West Virginia Department of Transportation and is housed at West Virginia University.

Are you on Facebook? Check out our page!

Type in Facebook.com/WVLTAP or within the search feature in Facebook, type WV Local Technical Assistance Program (WV LTAP). Be sure to "like" our page!

ltap West Virginia

WV Local Technical Assistance Program

Visit the LTAP Website.

Visit our site, located at **wvltap.wvu.edu**, to view training opportunities, request technical assistance, access publications such as our quarterly newsletter *Country Roads & City Streets,* and more! You can also update your mailing address and/or your email address.

Interested in Other LTAP Classes?

Seminars, workshops, and training sessions are scheduled both on-demand and at pre-set times. We hold classes at numerous locations across the state, and our trainers can also be scheduled to come to your location. Course descriptions and a calendar of events are available on our website, wvltap.wvu.edu. You can also contact any of the WV LTAP staff to learn more.

PO Box 6103 • Morgantown, WV 26505 • 304-293-9924 or 304-293-9939 • wvltap.wvu.edu

Proper Signs & Markings

Roads Scholar I Course

WV Local Technical Assistance Program

Course Objectives

- Introduce/Review the applicable standards
- Explain the fundamental principles
- Identify practices to reduce crashes and improve safety

Agenda

- MUTCD & Traffic Control Devices
- Signs
  - Retroreflectivity
- Markings
  - Retroreflectivity
- Maintenance for Safety
- Inventories
- *Quiz*
- *Evaluation*

What is a TCD?

- Anything that
  - Regulates traffic
  - Warns of hazards
  - Guides the driver
- Examples
  - Traffic signals
  - Signs
  - ?

History

- Auto clubs realized need ~1900
- Signs used to mark routes
- Competition

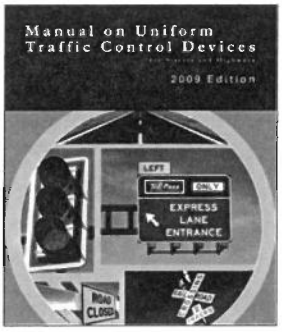
History

- First centerline
  - Michigan 1911
- First electric traffic signal
  - Cleveland 1914
- First STOP sign
  - Detroit 1915

MUTCD Over Time

Notable MUTCD Event

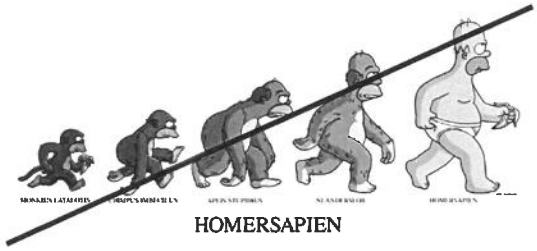
- 1966 Highway Safety Act (23 U.S.C. § 401)
  - States form Safety Program
  - Adopt MUTCD (23 C.F.R. 655.603)
  - Penalty: 10% Reduction



MUTCD

- http://mutcd.fhwa.dot.gov
- *"...shall be recognized as the national standard for all traffic control devices installed on any street, highway, or bicycle trail open to public travel..."*

Evolution...



HOMERSAPIEN

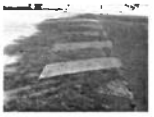
...of MUTCD

MUTCD Language

- Shall
  - Mandatory condition
- Should
  - Recommended but not mandatory; need a good reason to deviate
- May
  - Permitted, Option that can be used, but not required
- Sec. 1A.07: *"The responsibility for the design, placement, operation, maintenance, and uniformity of traffic control devices shall rest with the public agency or the official having jurisdiction."*

Principles of Traffic Control Devices

1. Fulfill a need
2. Command attention
3. Convey a clear, simple meaning
4. Command respect from road users
5. Give adequate time for proper response



5 Factors to Ensure These Principles Are Met:

1. Design
   - Size, Color, Shape, Retroreflectivity

5 Factors to Ensure These Principles Are Met:

2. Placement
   - Within cone of vision
   - Positioned with respect to situation to which it applies
   - Located to give driver proper response time

5 Factors to Ensure These Principles Are Met:

3. Application
   - Use appropriate devices

5 Factors to Ensure These Principles Are Met:

4. Maintenance
   - Assure legibility
   - Night viewing

5 Factors to Ensure These Principles Are Met:

5. Uniformity
   - Aids in recognition
   - Everyone interprets the device the same way

Sign Classification

- Regulatory
  - To inform users of traffic laws & regulations
- Warning
  - To warn motorists of hazards
- Guide
  - To provide information to aid motorists in reaching their destination

Yellow	Warning
Red	Stop or Prohibition
Blue	Motorists/Tourists Services; Evacuation Route
Green	Direction Guidance/Permission
Brown	Guidance for Recreational/Cultural Interests
Orange	Temporary Traffic Control (Construction/Maintenance)
Black	Regulation
White	Regulation
Fluorescent Pink	Incident Management
Fluorescent Yellow-Green	Warning for Peds, Bicyclists, Playgrounds, Schools

Sign Colors (MUTCD)

Sign Visibility

- Shall show same color & message both daytime and nighttime
- How do we accomplish this at night?

Retroreflectivity

Retroreflectivity

- Ability of a surface to return light back to its source
- Signs and pavement markings bounce light from vehicle headlights back toward the vehicle and driver's eyes

Visibility Needs

- Visibility of retroreflective traffic signs & markings depends on:

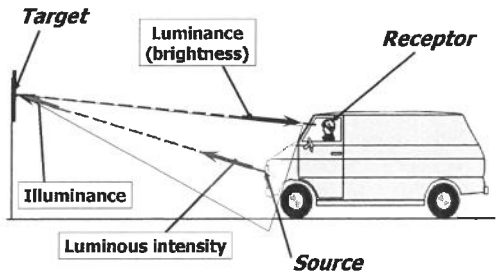
Sign


Headlamps

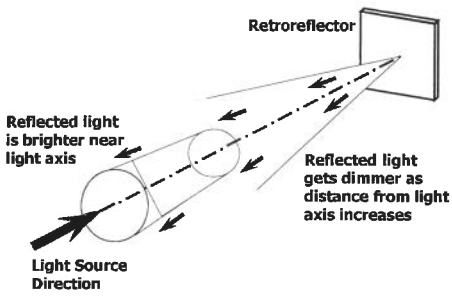
Driver


Vehicles

Retroreflectivity Elements & Photometrics



Retroreflectivity Cone



New MUTCD Sign Retroreflectivity Requirements

- Revision to 2003 MUTCD effective 1/22/08
- Milestones for agencies
  - Jan. 2012
    - Implementation & continued use of sign assessment and/or management method
  - Jan. 2015
    - Regulatory, warning, & ground-mounted guide signs
  - Jan. 2018
    - Overhead guide signs & street name signs

www.fhwa.dot.gov/retro

Standard Sign Shapes

Octagon — Exclusively for STOP signs

Equilateral Triangle, Point Down — Exclusively for YIELD signs

Circle — Exclusively for Railroad Advance Warning and Civil Defense Evacuation Route marker

Pennant — Exclusively for NO PASSING ZONE signs

Standard Sign Shapes

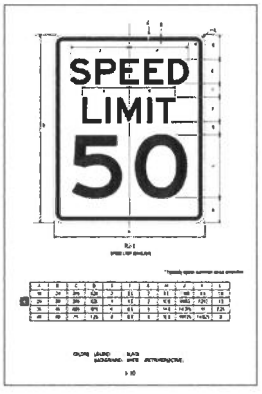
- Diamond — Used for warning signs
- Rectangle, Longer Dimension Vertical — Used for regulatory signs
- Rectangle, Longer Dimension Horizontal — Used for guide signs
- Trapezoid — Used for recreational area guide signs

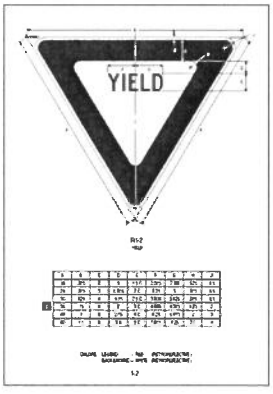
Standard Sign Shapes

- Pentagon — Used for school advance warning signs
- Crossbuck — Used for railroad crossing signs
- Other shapes — Used for route marker signs

Sign Size / Dimensions

http://mutcd.fhwa.dot.gov/ser-shs_millennium_eng.htm



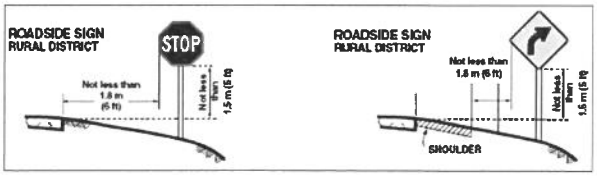


Typical Sign Dimensions

Sign	Conventional Road
Stop	30" X 30"
Yield	36" X 36" X 36"
Speed Limit	24" X 30"
Turn Prohibitions	24" X 24"
No-Parking	12" X 18"
Warning	Varies

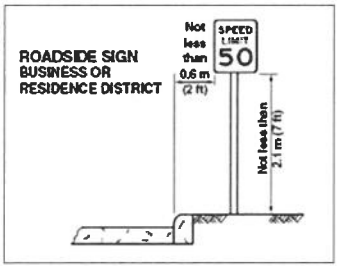
Sign Mounting Height

- Rural
  - 5-ft from sign bottom to near edge of road surface



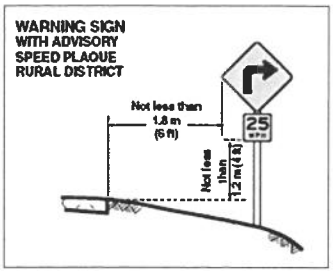
Sign Mounting Height

- Urban/Residential
  - 7-ft from sign bottom



Sign Mounting Height

- Secondary sign mounted below another
  - 1-ft less than noted above

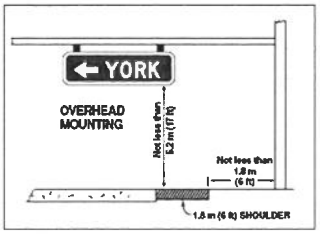


Sign Mounting Height

- Expressways/Freeways
  - Directional signs: min. 7-ft
  - Secondary sign mounted below another
    - Major sign: min. 8-ft
    - Secondary sign: min. 5-ft
  - Rte. markers, warning, regulatory signs: min. 7-ft

Sign Mounting Height

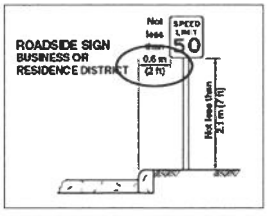
- Expressways/Freeways cont....
  - Overhead signs: vertical clearance min. 17-ft
    - Or 1-ft higher than vertical clearance of other structure (e.g. low clearance bridge)

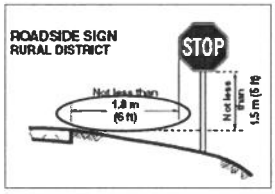


Lateral Offset

- General Guidance:
  - Should be 6-ft from edge of shoulder
  - If no shoulder, 12-ft from edge of traveled way
- Urban
  - 2-ft from curb face
  - 1-ft permissible where width limited
- Expressways
  - Shall be 6-ft from usable shoulder/unmountable curb
  - Should not be less than 10-ft from lane edge

Lateral Offset





Sign Supports

- "…shall be constructed to hold signs in proper & permanent position and to resist swaying in the wind or displacement by vandalism…"
- AASHTO's "*Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals*"

Sign Supports

- "Ground-mounted sign supports shall be breakaway, yielding, or shielded … if within the clear zone"
- Breakaway:
  - break or bend upon impact
  - includes those that separate from the base & are knocked ahead of or up & over errant vehicle
  - among most common: wood posts
    - one or two 4x4 Southern Pine or Douglas Fir posts
    - larger wood posts must be drilled & positioned in specific ways to ensure that they break in a consistent & predictable manner
  - steel posts
    - slip base breakaway mechanism
- Yielding:
  - those that bend, allowing a vehicle to run over them
- Shielded:
  - with barrier, such as guardrail, or a crash cushion

Sign Classification

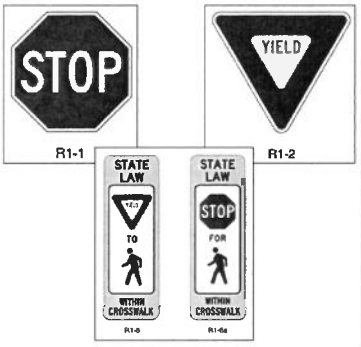
- Regulatory
- Warning
- Guide

REGULATORY SIGNS

- *"…shall be used to inform road users of selected traffic laws or regulations…"*
- *"…shall be installed at or near where the regulations apply…"*

Regulatory Signs

- Right-of-way series
  - STOP (R1-1)
  - YIELD (R1-2)
  - In-street pedestrian crossing signs (R1-6, 6a)



Regulatory Signs

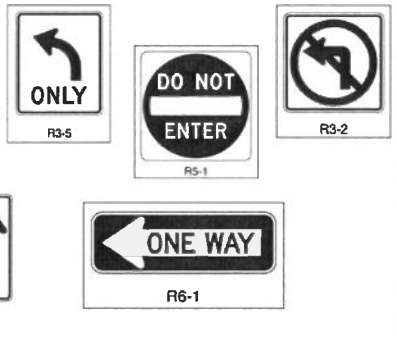
- Speed series
  - Speed Limit Sign (R2-1)
    - In multiples of 5 mph
    - Should be within 5 mph of 85th %tile speed of free-flowing traffic

Speed Limit Signs

- Locate at:
  - Points where speed limits change
  - Past major intersections
  - At state borders
  - At city limits
  - Through the zone, at intervals

Regulatory Signs

- Movement series
  - Turning
  - Lane Control
  - Exclusion
  - One-way

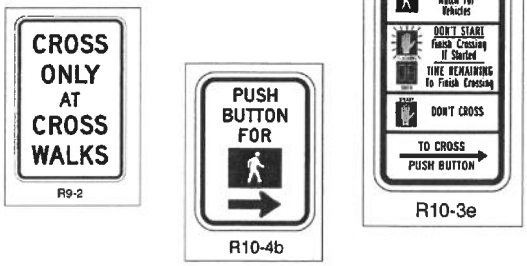


Regulatory Signs

- Parking

Regulatory Signs

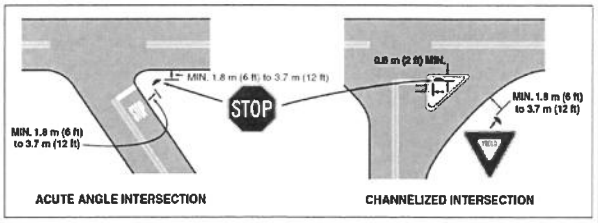
- Pedestrian Crossing



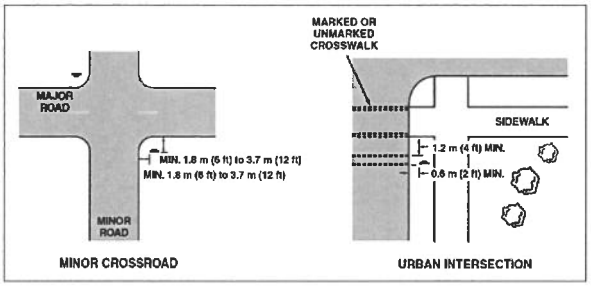
Regulatory Signs

- Others...

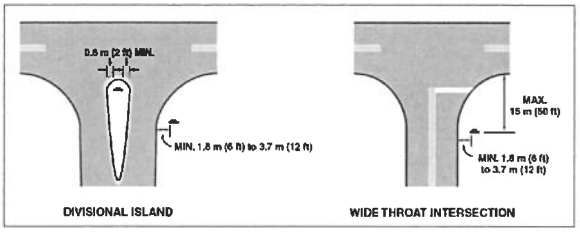
Locations of Typical Signs/Markings at Intersections



Locations of Typical Signs/Markings at Intersections



Locations of Typical Signs/Markings at Intersections



Correct Sign Locations??

Sign Classification

- Regulatory
- Warning
- Guide

WARNING SIGNS

- *"…call attention to unexpected conditions on or adjacent to a highway or street and to situations that might not be readily apparent to road users…"*
- Use should be kept to minimum since unnecessary use leads to disrespect for all signs

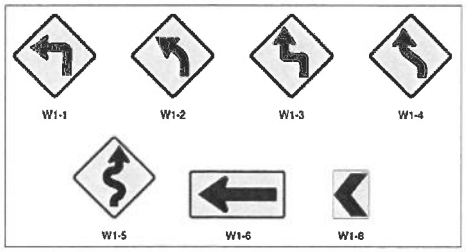
Warning Signs

- Typical locations & hazards:
  - Curves
  - Intersections
  - Advance warning of control devices
  - Converging traffic lanes
  - Narrow roadways
  - Grades
  - Surface conditions
  - Railroad crossings
  - School zones

Warning Signs

Warning Signs

- Horizontal Alignment Signs

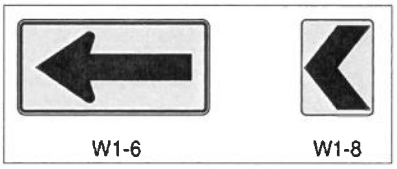


Horizontal Sign Usage

Number of Alignment Changes	Advisory Speed	
	≤ 30 MPH	> 30 MPH
1		
2		
3		

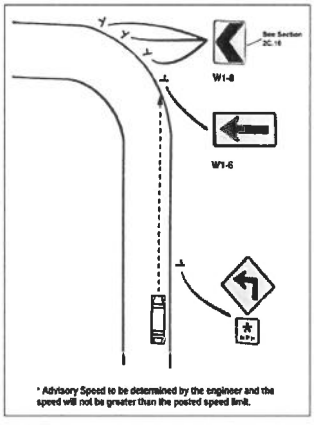
Warning Signs

- One-direction large arrow
- Chevron alignment



Chevron Alignment Spacing

- On outside of turn or curve
- In line with & at approximately right angle
- Spaced such that road user always has at least 2 in view until the change in alignment eliminates need for signs
- Should be visible for sufficient distance to provide adequate response time



Typical Installation for Chevron and/or Large Arrow

Guidelines for Advance Placement of Warning Signs

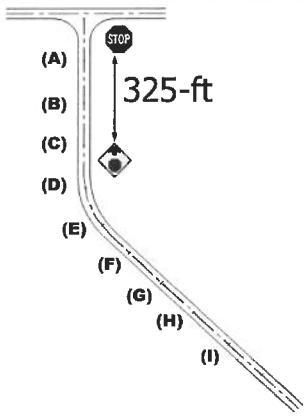
- ...so that they provide adequate PIEV time
  - Perception
  - Identification
  - Emotion
  - Volition

- Table 2C-4 MUTCD 2003 Edition

Guidelines for Advance Placement of Warning Signs

Table 2C-4. Guidelines for Advance Placement of Warning Signs (English Units)

Posted or 85th-Percentile Speed	Advance Placement Distance [1]								
	Condition A: Speed reduction and lane changing in heavy traffic[2]	Condition B: Deceleration to the listed advisory speed (mph) for the condition[3]							
		0*	10	20	30	40	50	60	70
20 mph	225 ft	N/A[4]	N/A[4]	—	—	—	—	—	—
25 mph	325 ft	N/A[4]	N/A[4]	N/A[4]	—	—	—	—	—
30 mph	450 ft	N/A[4]	N/A[4]	N/A[4]	—	—	—	—	—
35 mph	550 ft	N/A[4]	N/A[4]	N/A[4]	N/A[4]	—	—	—	—
40 mph	650 ft	125 ft	N/A[4]	N/A[4]	N/A[4]	—	—	—	—
45 mph	750 ft	175 ft	125 ft	N/A[4]	N/A[4]	N/A[4]	—	—	—
50 mph	850 ft	250 ft	200 ft	150 ft	100 ft	N/A[4]	—	—	—
55 mph	950 ft	325 ft	275 ft	225 ft	175 ft	100 ft	N/A[4]	—	—
60 mph	1100 ft	400 ft	350 ft	300 ft	250 ft	175 ft	N/A[4]	—	—
65 mph	1300 ft	475 ft	425 ft	400 ft	350 ft	275 ft	175 ft	N/A[4]	—
70 mph	1250 ft	550 ft	525 ft	500 ft	425 ft	350 ft	250 ft	150 ft	—
75 mph	1350 ft	650 ft	625 ft	600 ft	525 ft	450 ft	350 ft	250 ft	100 ft



Sign Location Problem#1

Posted Speed = 55 mph

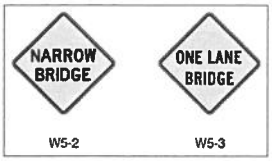
"Stop Ahead" sign needed

Each tic mark = 100-ft

Where would the "Stop Ahead" sign be located?

As per Table 2C-4.....

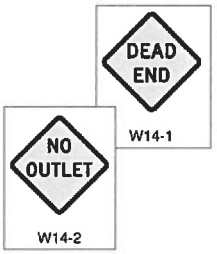
"Narrow Bridge" vs "One Lane Bridge"



- "Narrow Bridge": in advance of any bridge or culvert having a 2-way clearance width of 16-18ft or clearance less than width of approach travel lanes
- "One Lane Bridge: on 2-way roads in advance of any bridge or culvert having a clear width of < 16-ft, < 18-ft with high % of trucks, ≤ 18-ft where sight distance is limited on approaches

"Dead End" vs "No Outlet"

- "Dead End": at entrance of a single road or street that terminates in a dead end or cul-de-sac
- "No Outlet": at entrance to a road or road network from which there is no other exit



"Watch for Children" Sign

- Not recognized by FHWA
- Not found in MUTCD
- Send ambiguous message
- Give false sense of security
- NOT Recommended

Warning: Pedestrian Crossing

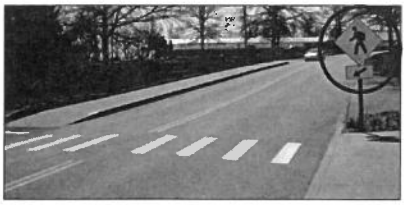
Standard changed with 2000 MUTCD

Warning: Pedestrian Crossing

- *"...the mixing of standard yellow & fluorescent yellow-green backgrounds within a selected site area should be avoided"*

Right or Wrong?

Right or Wrong?



Right or Wrong?

- *"When used at the crossing…shall be supplemented with a diagonal downward pointing arrow plaque showing the location of the crossing."*

Right or Wrong?

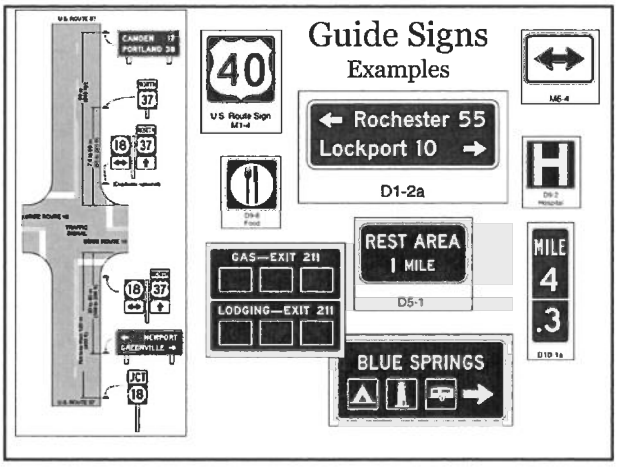
- In-Street Pedestrian Crossing sign (R1-6 or R1-6a) used to remind users of laws regarding r-o-w at unsignalized ped crossing
- *"…shall have a black legend and border on either a white and/or fluorescent yellow-green background."*

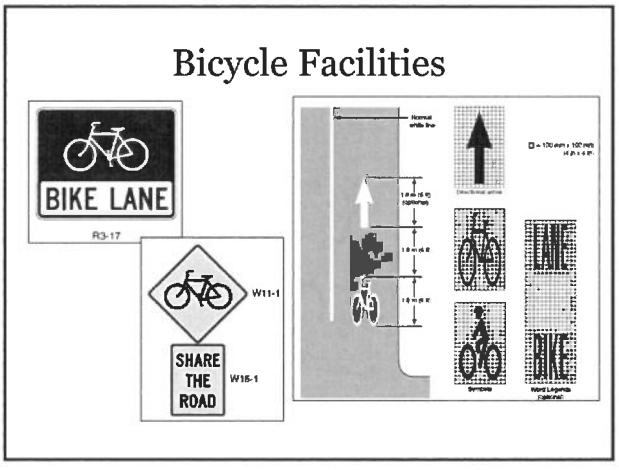
Sign Classification

- Regulatory
- Warning
- Guide

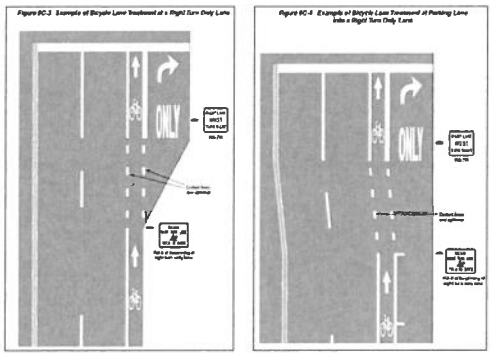
GUIDE SIGNS

- *"…essential to direct road users along streets & highways, to inform them of intersecting routes, to direct them to cities, towns, villages, or other important destinations, to identify nearby rivers and streams, parks, forests, & historical sites…"*
- Get you from "A" to "B" in the most simple, direct manner possible

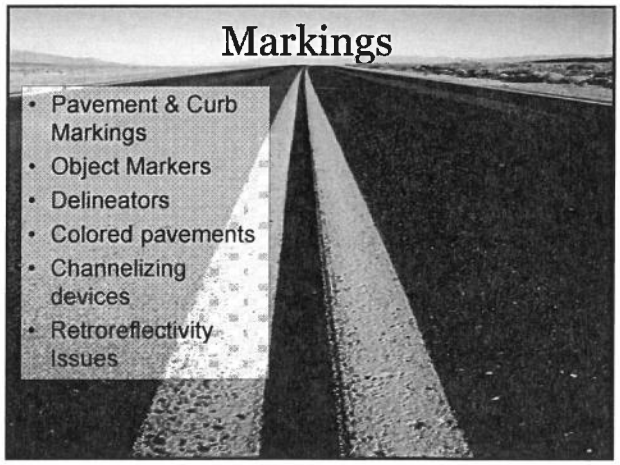




Bicycle Facilities



Markings



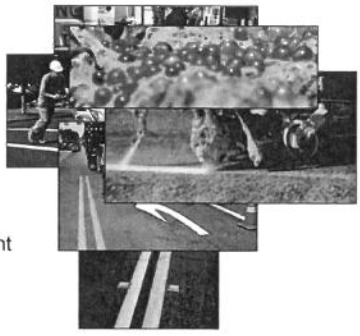
- Pavement & Curb Markings
- Object Markers
- Delineators
- Colored pavements
- Channelizing devices
- Retroreflectivity Issues

Limitations of Markings

- Visibility limited by:
  - Snow
  - Debris
  - Water
- Durability affected by:
  - Material characteristics
  - Traffic volumes
  - Weather
  - Location

Pavement Markings

- Types
  - Paint
  - Thermoplastics
  - Preformed Tapes/Markings
  - Raised Pavement Markings



Pavement Markings

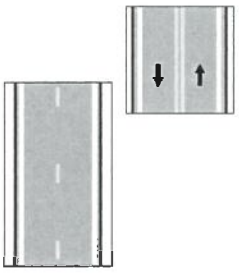
- Colors
  - White
    - Separates same-direction traffic
    - Right edge of roadway
  - Yellow
    - Separates opposite-direction traffic
    - Left edge of roadway on divided & one-way highways
    - Separates 2-way left turn lanes & reversible lanes
  - Red
    - Raised pavement markers
    - Delineates roadways that shall not be entered
  - Blue
    - Supplements white markings for parking spaces for disabled
  - Black
    - Used as contrast color

Pavement Markings

- Widths
  - Normal lines
    - 4 to 6 inches
  - Wide lines
    - 8 to 12 inches

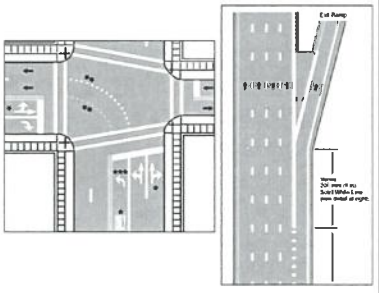
Pavement Markings

- 1 Solid line
  - Should not cross
- 2 Solid lines
  - Do not cross
- Lane lines
  - Can cross
  - 10-ft line, 30-ft gap
- Dotted lines
  - Lane Extension
  - 2-ft line, 4-ft gap



Pavement Markings

- Dotted lines
  - Provides guidance
  - Line extension
    - 2-ft line, 2 to 6-ft gap
  - Lane drop/add
    - 3-ft line, 9-ft gap



Center Line

- Shall be placed:
  - Urban arterials & collectors
    - > 20-ft wide & > 6,000 veh/day
  - 2-way streets or highways w/ 3 or more travel lanes
  - Undivided highways of 4 or more lanes
- Recommended for:
  - Urban arterials & collectors
    - > 20-ft wide & > 4,000 veh/day
  - Rural arterial & collectors
    - > 18-ft wide & > 3,000 veh/day

Edge Line

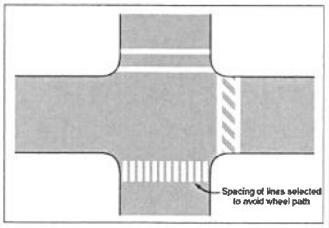
- Shall be placed:
  - Freeways
  - Expressways
  - Rural arterials
    - > 20-ft wide & > 6,000 veh/day
- Edge lines recommended for:
  - Rural arterials & collectors
    - > 20-ft wide & > 3,000 veh/day

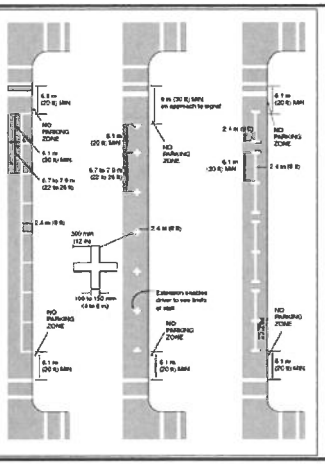
Pavement Markings

- Stop lines
  - Indicate point behind which vehicles are required to stop in compliance w/ Stop sign, traffic signal control, etc.
  - 12 to 24 inches wide
  - Min. 4-ft in advance of crosswalk line
  - 4 to 30 feet from nearest edge of intersecting traveled way

Pavement Markings

- Crosswalks
  - Shall be:
    - Solid white lines
    - Min. 6-inches wide; max 24-inches
  - Should be:
    - At least 6-ft wide
    - Marked at all intersections with substantial conflict between vehicular & pedestrian movements





Pavement Markings

- Parking Space Markings
  - Shall be white
  - Option: blue lines for disabled parking

Retroreflectivity of Pavement Markings

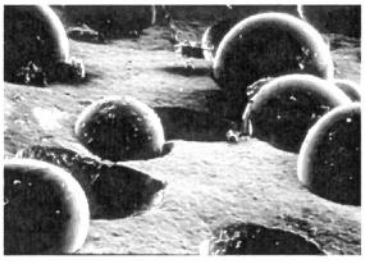


Figure 2.8
Magnified view of reflective beads at proper embedment depth

Retroreflectivity of Pavement Markings

http://safety.fhwa.dot.gov/tools/retro_trafficcontrol.htm

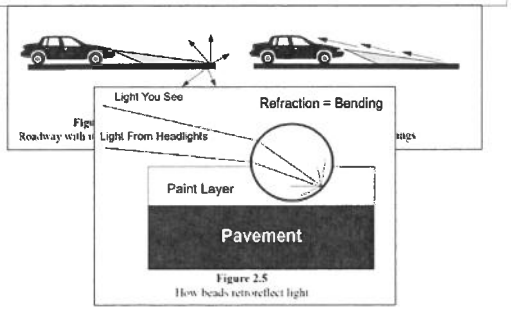


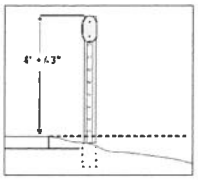
Figure 2.5
How beads retroreflect light

Delineators

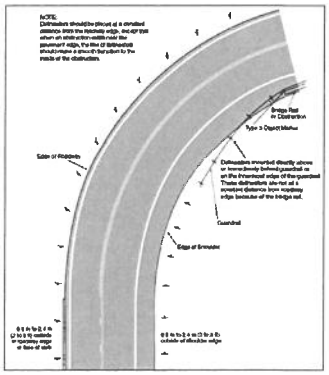
- Used in series to indicate alignment of roadway (more so on freeways & expressways)
- Considered guidance devices rather than warning
- Beneficial at locations where alignment might be confusing or unexpected
  - Lane reduction transitions
  - Curves
- Effective at night & during adverse weather
- Shall be retroreflective
- Retroreflective elements min. 3-inches wide

Delineators

- Color shall conform to color of edge lines
- Top of highest retroreflector 4-ft above roadway
- Placed 2 to 8-ft from shoulder edge
- Spaced 200 to 530-ft apart on tangent sections
- Spaced closer on curves so that several are simultaneously viewed
  - 20 to 90-ft apart, based on curve radius



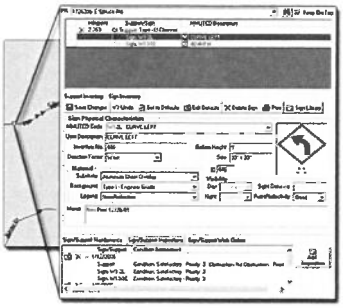
Delineators



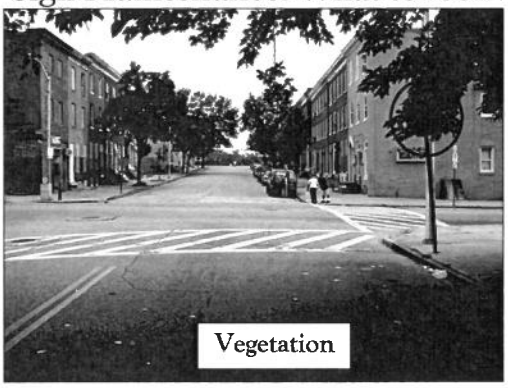
Components of a Sign Maintenance System

- Sign inventory
- Citizen complaint system
- Method for rating maintenance priorities
- Routine inspection program

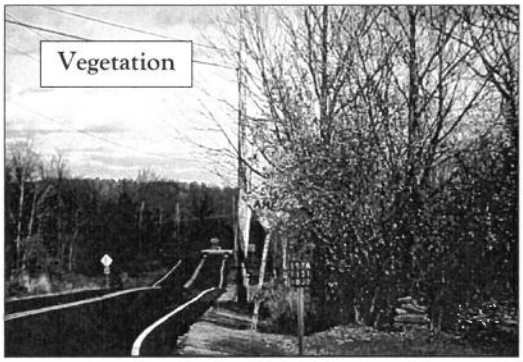
Inventories



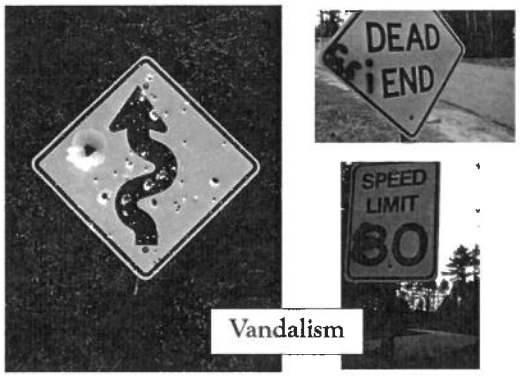
Sign Maintenance: What to look for?



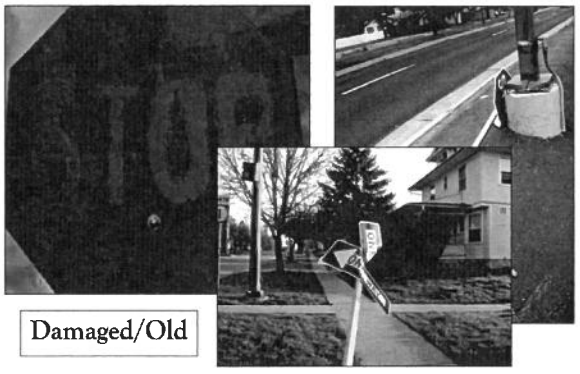
Sign Maintenance: What to look for?

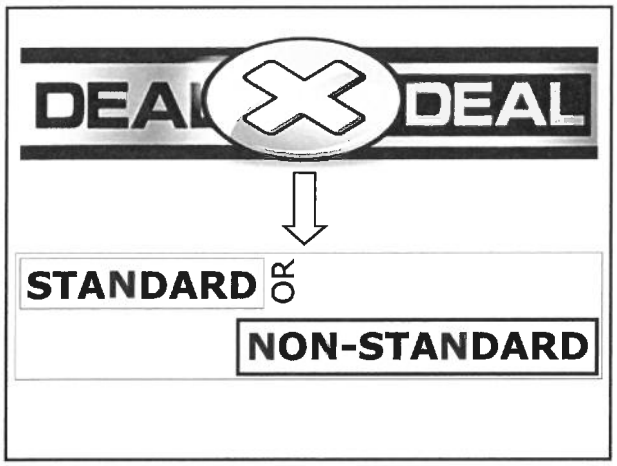


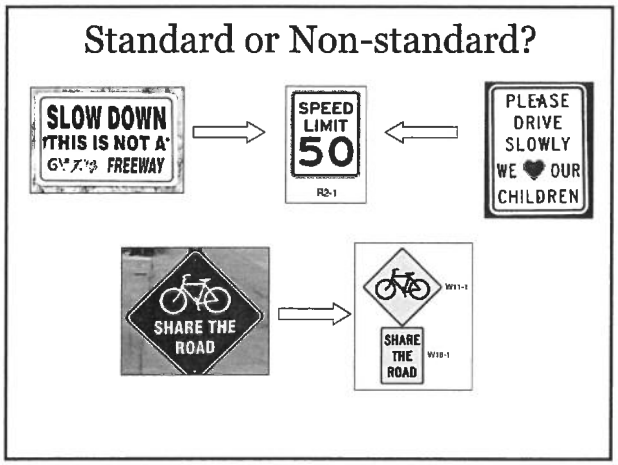
Sign Maintenance: What to look for?

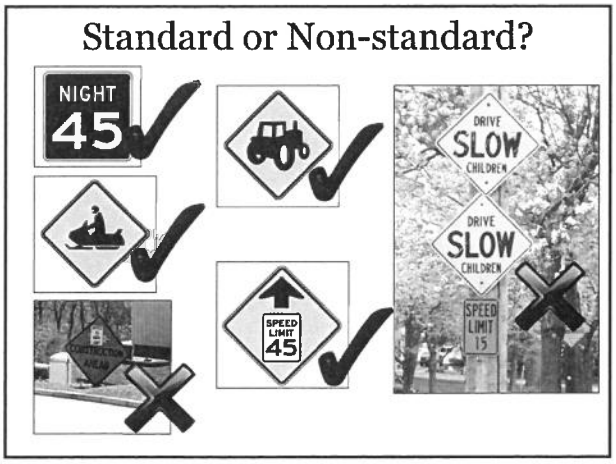


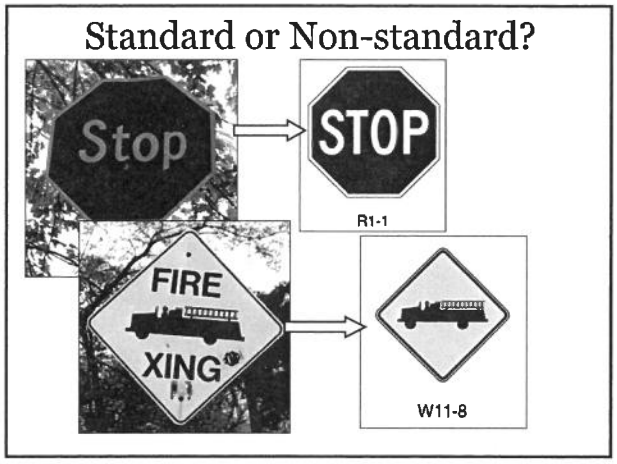
Sign Maintenance: What to look for?



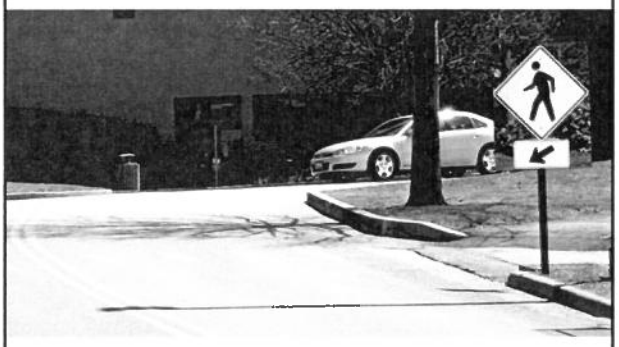

DEAL
DEAL
STANDARD
OR
NON-STANDARD


Standard or Non-standard?
SLOW DOWN
THIS IS NOT A
FREEWAY
SPEED
LIMIT
50
R2-1
PLEASE
DRIVE
SLOWLY
WE ♥ OUR
CHILDREN
SHARE THE
ROAD
SHARE
THE
ROAD


Standard or Non-standard?
NIGHT
45
SPEED
LIMIT
45
DRIVE
SLOW
CHILDREN
DRIVE
SLOW
CHILDREN
SPEED
LIMIT
15


Standard or Non-standard?
Stop
STOP
R1-1
FIRE
XING
W11-8

Standard or Non-standard?



Questions?

Contact for Further Reference

West Virginia Local Technical Assistance Program
http://wvltap.wvu.edu

Program Coordinator
PO Box 6103
Morgantown, WV 26506

304-293-3031 x 2629
304-293-7109
@mail.wvu.edu

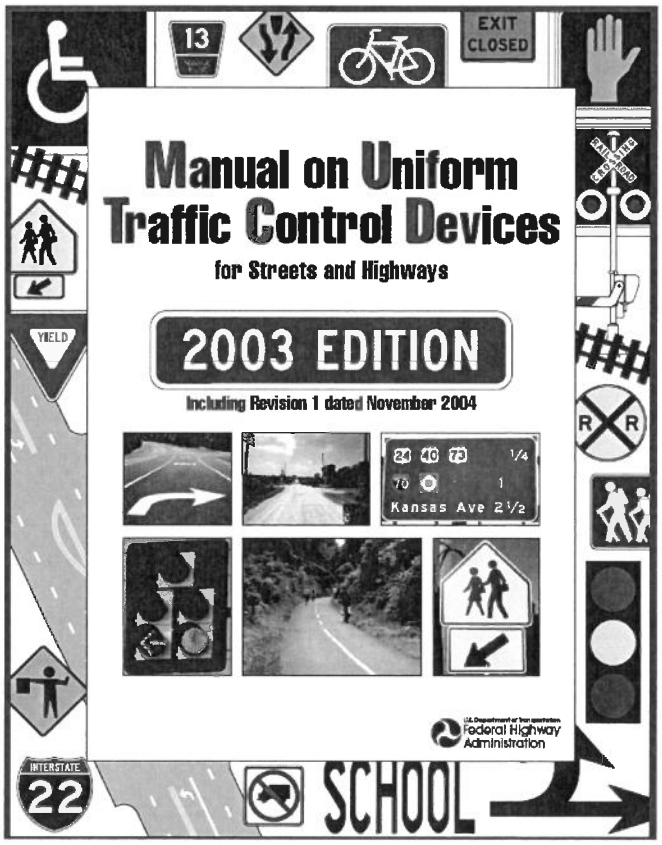
Evolution of MUTCD

Year	Name of Manual	Month/Yr Revised
1927	Manual & Specifications for the Manufacture, Display, & Erection of U.S. Standard Road Markers & Signs (for rural roads)	4/29, 12/31
1930	Manual on Street Traffic Signs, Signals, & Markings (for urban streets)	No revisions
1935	Manual on Uniform Traffic Control Devices for Streets & Highways (MUTCD)	2/39
1942	Manual on Uniform Traffic Control Devices for Streets & Highways – War Emergency Edition	No revisions
1948	Manual on Uniform Traffic Control Devices for Streets & Highways	9/54
1961	Manual on Uniform Traffic Control Devices for Streets & Highways	No revisions
1971	Manual on Uniform Traffic Control Devices for Streets & Highways	11/71, 4/72, 3/73, 10/73, 6/74, 6/75, 9/76, 12/77
1978	Manual on Uniform Traffic Control Devices for Streets & Highways	12/79, 12/83, 9/84, 3/86
1988	Manual on Uniform Traffic Control Devices for Streets & Highways	1/90, 3/92, 9/93, 11/94, 12/96, 6/98, 1/00
2000	Manual on Uniform Traffic Control Devices for Streets & Highways – Millennium Edition	7/02
2003	Manual on Uniform Traffic Control Devices for Streets & Highways	???

Note the major milestones of the MUTCD, including:

- 1st edition (1927)
- 1st time officially referred to as "MUTCD" (1935)
- Referred to as "War Emergency Edition" (1942)
- Major updates in "Millennium Edition" (2000)

The following four (4) pages are excerpts from the most recent Manual on Uniform Traffic Control Devices.



The whole document can be accessed via the internet at the following links:

http://mutcd.fhwa.dot.gov/pdfs/2003r1/pdf-index.htm (PDF version)

http://mutcd.fhwa.dot.gov/HTM/2003r1/html-index.htm (HTML version)

Table 2A-4. Common Uses of Sign Colors

Type of Sign	Legend					Background									
	Black	Green	Red	White	Yellow	Black	Blue	Brown	Green	Orange	Red	White	Yellow	Fluorescent Yellow-Green	Fluorescent Pink
Regulatory	X		X	X		X					X	X			
Prohibitive			X	X							X	X			
Permissive		X										X			
Warning	X												X		
Pedestrian	X												X	X	
Bicycle	X												X	X	
Guide				X					X						
Interstate Route				X			X				X				
State Route	X											X			
US Route	X											X			
County Route					X		X								
Forest Route				X				X							
Street Name				X					X						
Destination				X					X						
Reference Location				X					X						
Information				X			X		X						
Evacuation Route				X			X								
Road User Service				X			X								
Recreational				X				X	X						
Temporary Traffic Control	X									X					
Incident Management	X									X					X
Changeable Message Signs *				X	X	X									
School	X												X	X	

* Reverse colors or fluorescent yellow-green pixels may also be used on changeable message signs

---

Section 2A.14 Word Messages

Standard:

Except as noted in Section 2A.06, all word messages shall use standard wording and letters as shown in this Manual and in the "Standard Highway Signs" book (see Section 1A.11).

Guidance:

Word messages should be as brief as possible and the lettering should be large enough to provide the necessary legibility distance. A minimum specific ratio, such as 25 mm (1 in) of letter height per 12 m (40 ft) of legibility distance, should be used.

Support:

Some research indicates that a ratio of 25 mm (1 in) of letter height per 10 m (33 ft) of legibility distance could be beneficial.

Guidance:

Abbreviations (see Section 1A.14) should be kept to a minimum, and should include only those that are commonly recognized and understood, such as AVE (for Avenue), BLVD (for Boulevard), N (for North), or JCT (for Junction).

Table 2C-4. Guidelines for Advance Placement of Warning Signs
(English Units)

Posted or 85th-Percentile Speed	Advance Placement Distance [1]								
	Condition A: Speed reduction and lane changing in heavy traffic[2]	Condition B: Deceleration to the listed advisory speed (mph) for the condition[4]							
		0[3]	10	20	30	40	50	60	70
20 mph	225 ft	N/A[5]	N/A[5]	—	—	—	—	—	—
25 mph	325 ft	N/A[5]	N/A[5]	N/A[5]	—	—	—	—	—
30 mph	450 ft	N/A[5]	N/A[5]	N/A[5]	—	—	—	—	—
35 mph	550 ft	N/A[5]	N/A[5]	N/A[5]	N/A[5]	—	—	—	—
40 mph	650 ft	125 ft	N/A[5]	N/A[5]	N/A[5]	—	—	—	—
45 mph	750 ft	175 ft	125 ft	N/A[5]	N/A[5]	N/A[5]	—	—	—
50 mph	850 ft	250 ft	200 ft	150 ft	100 ft	N/A[5]	—	—	—
55 mph	950 ft	325 ft	275 ft	225 ft	175 ft	100 ft	N/A[5]	—	—
60 mph	1100 ft	400 ft	350 ft	300 ft	250 ft	175 ft	N/A[5]	—	—
65 mph	1200 ft	475 ft	425 ft	400 ft	350 ft	275 ft	175 ft	N/A[5]	—
70 mph	1250 ft	550 ft	525 ft	500 ft	425 ft	350 ft	250 ft	150 ft	—
75 mph	1350 ft	650 ft	625 ft	600 ft	525 ft	450 ft	350 ft	250 ft	100 ft

Notes:

[1] The distances are adjusted for a sign legibility distance of 175 ft for Condition A. The distances for Condition B have been adjusted for a sign legibility distance of 250 ft, which is appropriate for an alignment warning symbol sign.

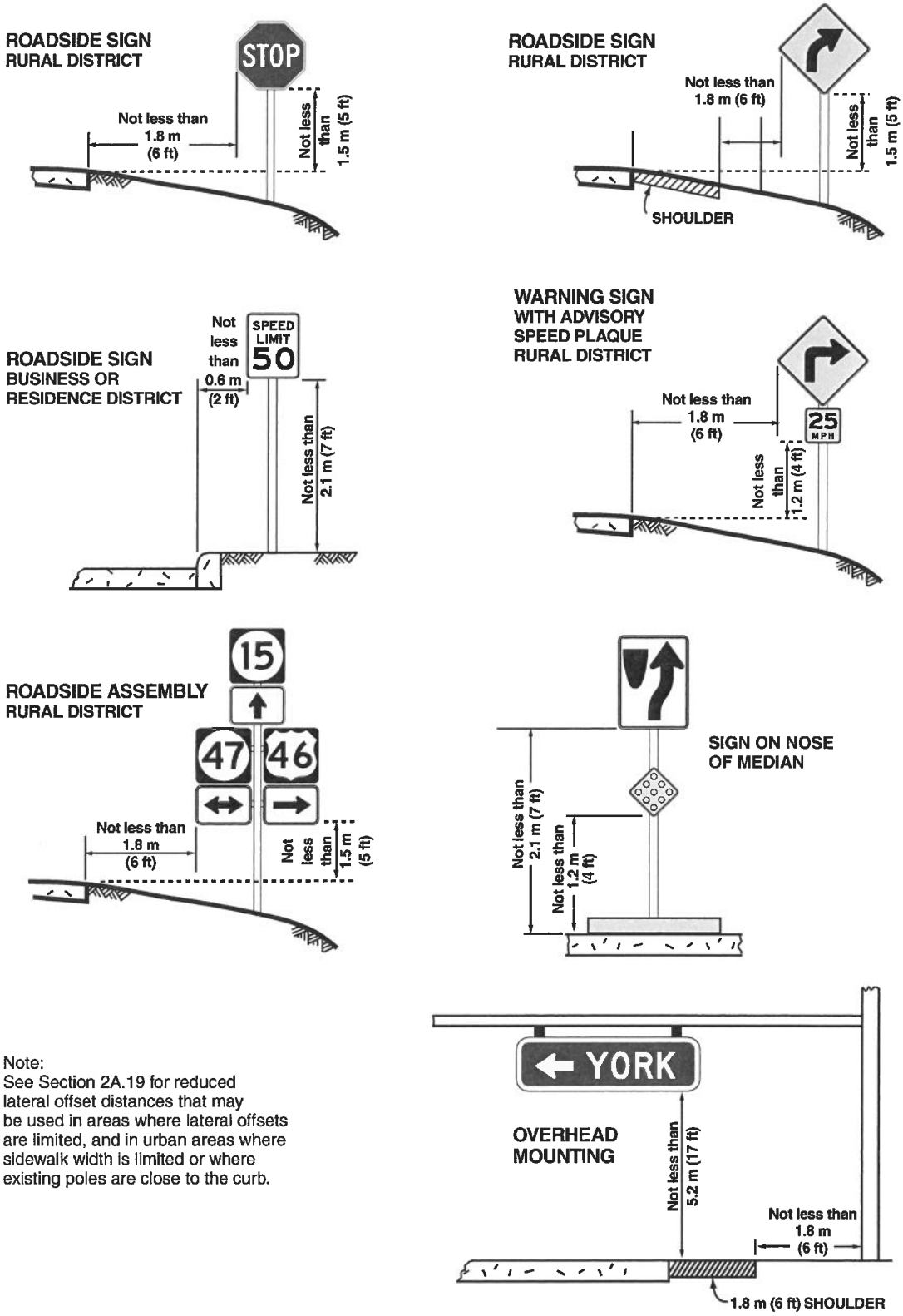
[2] Typical conditions are locations where the road user must use extra time to adjust speed and change lanes in heavy traffic because of a complex driving situation. Typical signs are Merge and Right Lane Ends. The distances are determined by providing the driver a PIEV time of 14.0 to 14.5 seconds for vehicle maneuvers (2001 AASHTO Policy, Exhibit 3-3, Decision Sight Distance, Avoidance Maneuver E) minus the legibility distance of 175 ft for the appropriate sign.

[3] Typical condition is the warning of a potential stop situation. Typical signs are Stop Ahead, Yield Ahead, Signal Ahead, and Intersection Warning signs. The distances are based on the 2001 AASHTO Policy, Stopping Sight Distance, Exhibit 3-1, providing a PIEV time of 2.5 seconds, a deceleration rate of 11.2 ft/second^2, minus the sign legibility distance of 175 ft.

[4] Typical conditions are locations where the road user must decrease speed to maneuver through the warned condition. Typical signs are Turn, Curve, Reverse Turn, or Reverse Curve. The distance is determined by providing a 2.5 second PIEV time, a vehicle deceleration rate of 10 ft/second^2, minus the sign legibility distance of 250 ft.

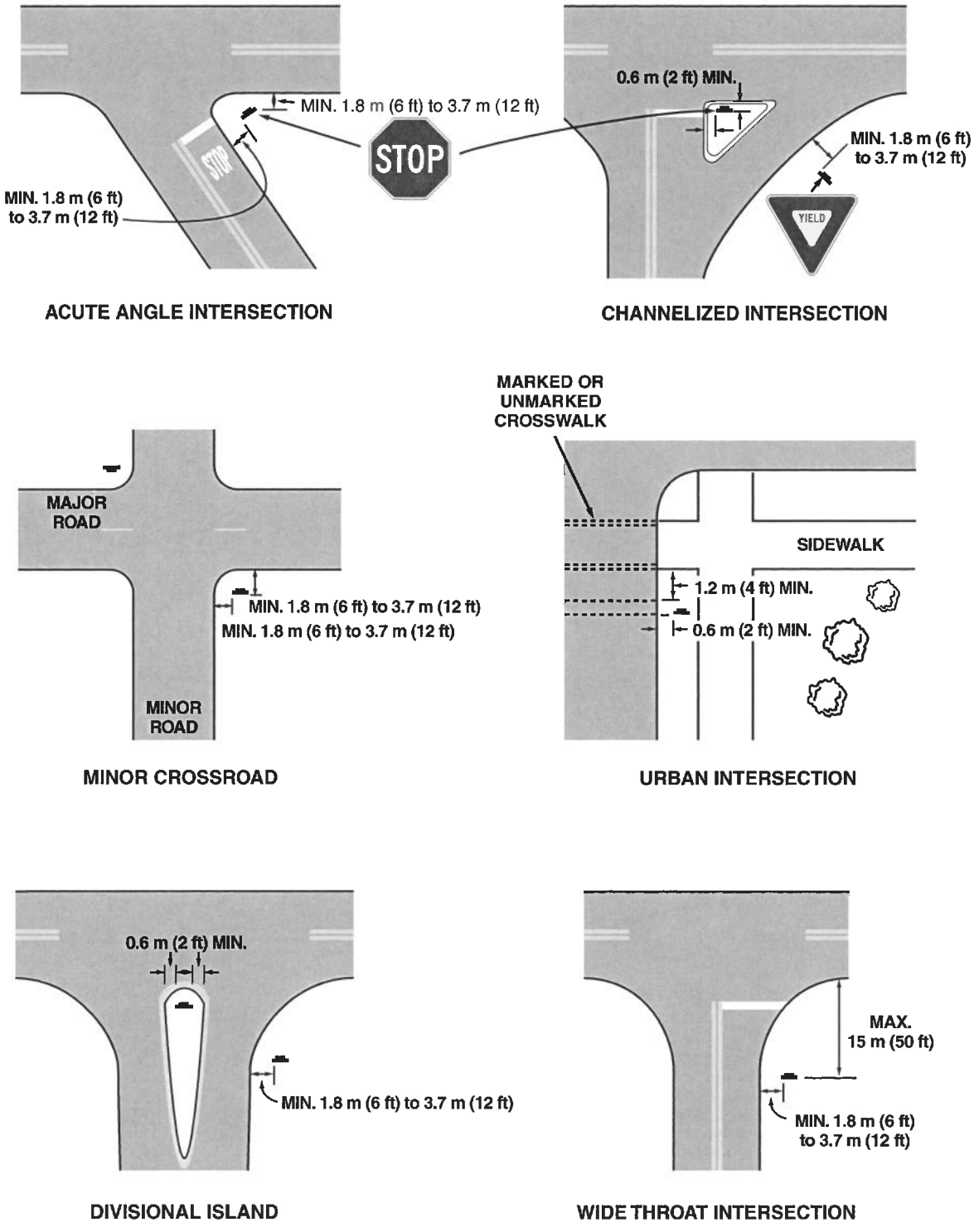
[5] No suggested distances are provided for these speeds, as the placement location is dependent on site conditions and other signing to provide an adequate advance warning for the driver.

Figure 2A-1. Examples of Heights and Lateral Locations of Signs for Typical Installations



Note:
See Section 2A.19 for reduced lateral offset distances that may be used in areas where lateral offsets are limited, and in urban areas where sidewalk width is limited or where existing poles are close to the curb.

Figure 2A-2. Examples of Locations for Some Typical Signs at Intersections

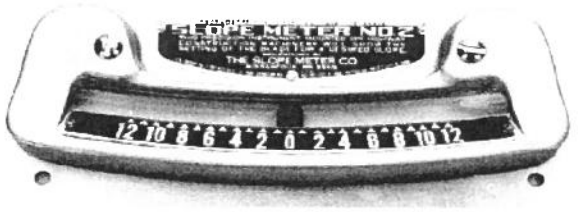


Note: Lateral offset is a minimum of 1.8 m (6 ft) measured from the edge of the shoulder, or 3.7 m (12 ft) measured from the edge of the traveled way. See Section 2A.19 for lower minimums that may be used in urban areas, or where lateral offset space is limited.

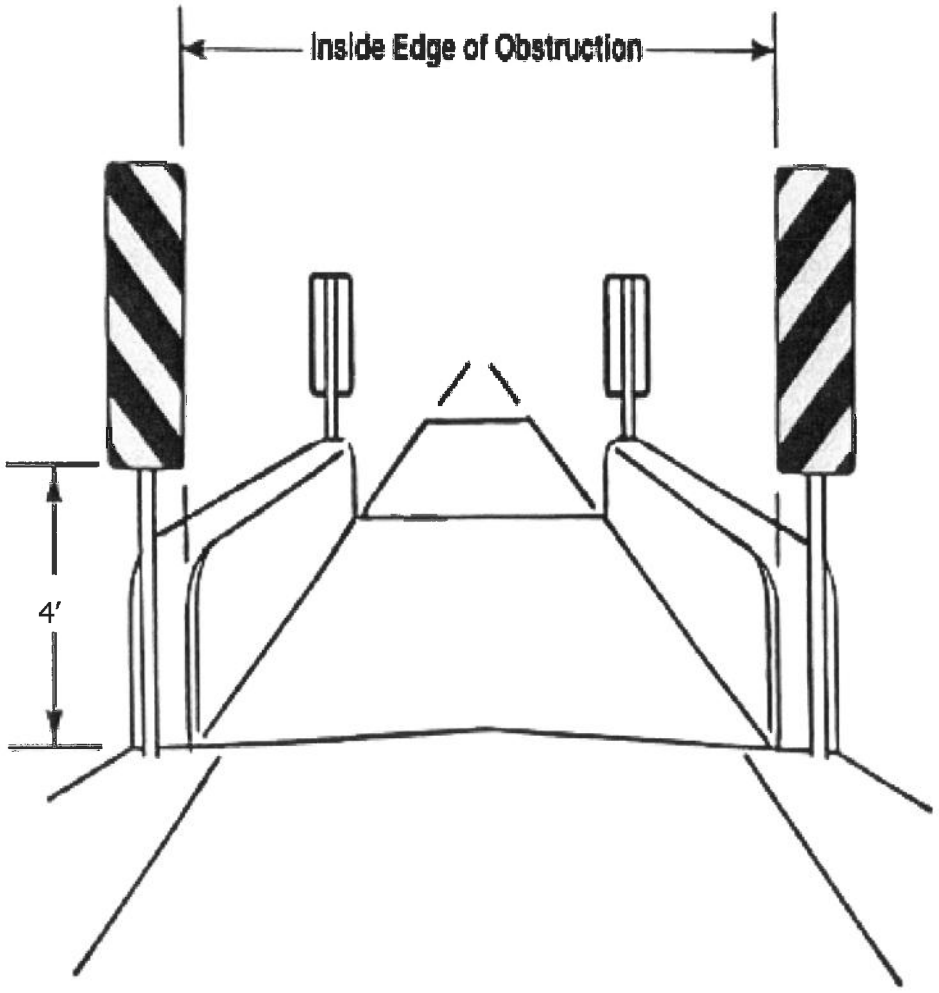
Advisory Safe Speed Determination

The Advisory Safe Speed of a curve can be determined by the use of a ball bank indicator, also known as a slope meter (see pictures below). The indicator will give a reading of ten (10) (when using the older versions; newer versions are digital and include an audible alarm) when the vehicle in which it is mounted negotiates a curve at the highest speed which is considered safe and comfortable.

The term "ball bank indicator" refers to an inclinometer that is used for the specific purpose of determining safe (uniform advisory) curve speeds for horizontal curves. It measures the overturning force (side friction), measured in degrees, on a vehicle negotiation a horizontal curve – whether it is an isolated curve, multiple "S" curve, or a ramp to/from a freeway.



Markings for Objects Adjacent to the Roadway



When object markers are installed below the normal mounting height of 4', the authority must keep weeds mowed in front of the signs and periodic cleaning is necessary for the signs to be visible.

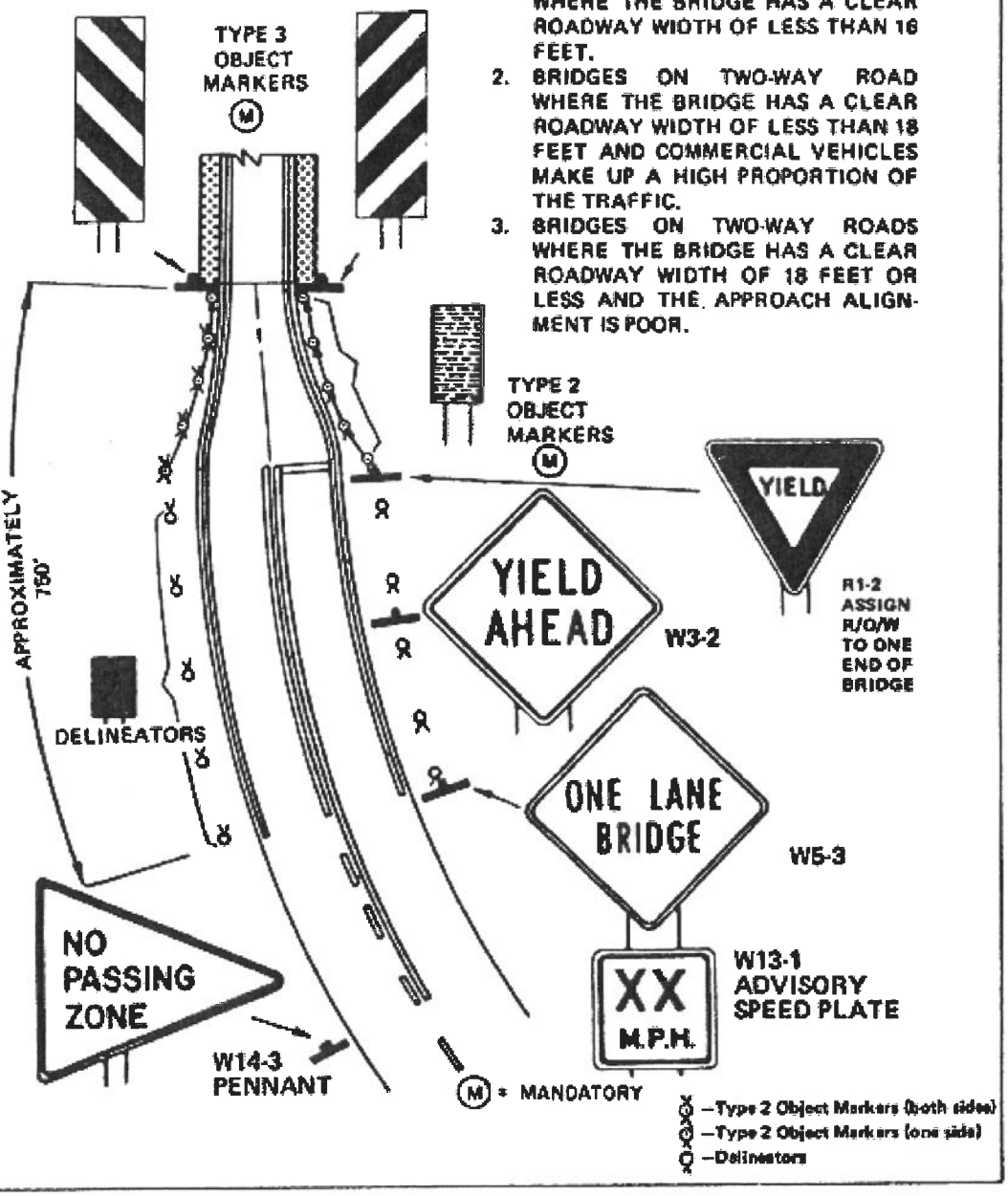
If used, the inside edge of the marker shall be in line with the inner edge of the obstruction.

ONE LANE BRIDGE ON A CURVE
TRAFFIC CONTROL DEVICE APPLICATION

WARNING SIGNS

ONE-LANE BRIDGES ARE DEFINED AS:

1. BRIDGES ON TWO-WAY ROADS WHERE THE BRIDGE HAS A CLEAR ROADWAY WIDTH OF LESS THAN 16 FEET.
2. BRIDGES ON TWO-WAY ROAD WHERE THE BRIDGE HAS A CLEAR ROADWAY WIDTH OF LESS THAN 18 FEET AND COMMERCIAL VEHICLES MAKE UP A HIGH PROPORTION OF THE TRAFFIC.
3. BRIDGES ON TWO-WAY ROADS WHERE THE BRIDGE HAS A CLEAR ROADWAY WIDTH OF 18 FEET OR LESS AND THE APPROACH ALIGNMENT IS POOR.



StreetWise
Spring 2007 Vol VI • #2

CORRECT SIGN INSTALLATION INCREASES MOTORIST SAFETY

Eighty-five percent of all motor vehicles that run off the road recover safely within 30 feet of the roadway in a clear zone, according to a recent study by General Motors.

Although a 30-foot clear zone is not always possible, it's a good concept to try to achieve. Fewer barriers adjacent to the road increases motorist safety.

- **Remove** fixed objects and provide traversable terrain.
- **Relocate** objects outside the clear zone.
- **Retrofit** objects that cannot be removed or relocated by making them breakaway or crashworthy.
- **Shield** the hazards that cannot be improved by installing guardrails, barriers or crash cushions.
- **Delineate** the hazard as a temporary measure if the methods above are impractical.

Hazards

Road signs often are placed in the clear zone so they will be in the driver's line of sight. Therefore, the construction of road sign posts and foundations is critical. Road signs should be placed on safe sign supports so that they do not become a bigger hazard than the situation they are meant to improve.

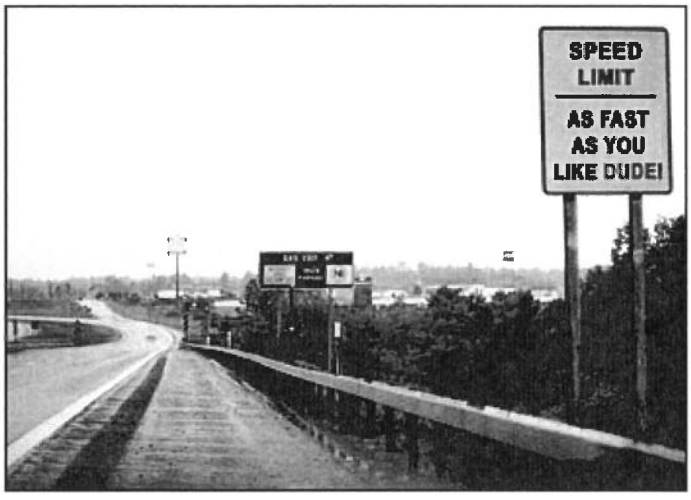
A support post must be able to hold a particular sign in the proper position and withstand normal loads from wind and other sources, yet safely yield when struck by a vehicle.

Placement

A sign placed close to the roadway is more likely to be struck than one that is set farther away. Whenever possible, place signs where they are not likely to be struck by out-of-control vehicles. The following are some considerations for placing road signs:

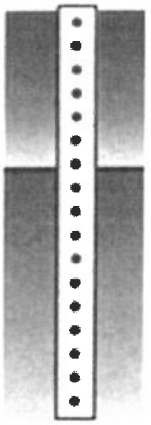
- Avoid placing signs on curves such as the outside of horizontal curves.
- Avoid placing signs next to lane drops or other places where the pavement narrows.
- Provide an unobstructed view of signs along the roadway.
- Place signs behind guardrails or other barriers whenever possible.
- Avoid placing signs in the bottom of ditches.
- Space signs along the roadway so they don't obstruct the view of each other.

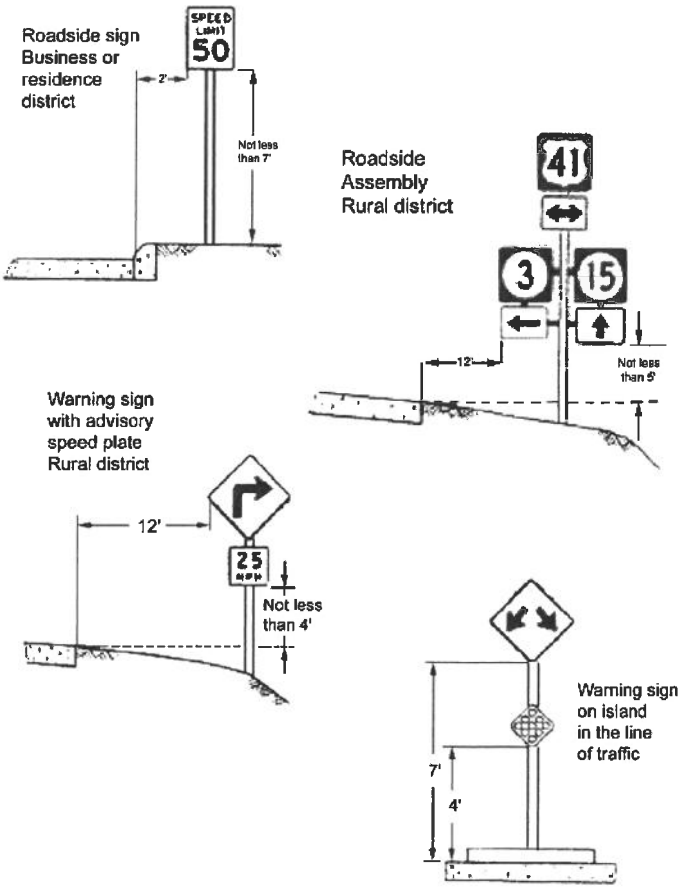
Recommended spacing is 100 feet to 200 feet apart. Signs should not be clustered together.



Sign installation tips

- Bury posts in firm ground 4 feet deep. Loose or sandy soil may require deeper post placement.
- Use breakaway sign supports to enhance roadside safety.
- Use sign connections that prevent vandalism.





Height

The *Manual on Uniform Traffic Control Devices* states: "Signs erected at the side of the road in rural districts shall be mounted at a height of at least 5 feet, measured from the bottom of the sign to the near edge of the pavement.

"In business, commercial and residential districts where parking and/or pedestrian movement is likely to occur or where obstructions are present, the clearance to bottom of the sign must be at least 7 feet. The height of the bottom of a secondary sign mounted below another sign may be one foot less than the appropriate height specified above."

Lateral clearance

Signs should have the maximum lateral clearance that is practical from the edge of the traveled roadway for the safety of motorists who might leave the roadway and strike the sign supports. Existing guardrails, overcrossing structures and other conditions should be used to minimize the exposure of sign supports to traffic. Otherwise, sign supports should be breakaway or yielding.

Normally, signs should not be closer than six feet from the edge of the shoulder, or 12 feet away from the edge of the traveled roadway if no shoulder is present. Although two feet are recommended as a working urban minimum, a clearance of one foot from the curb face is permissible where the sidewalk width is limited or where existing poles are close to the curb.

The diagrams show the proper height and lateral locations of signs. Note that the lateral placement of signs in rural districts is a six-foot minimum and out to 12 feet when possible.

U-channel steel posts

The U-channel rolled steel post is a common small sign support. It is considered breakaway because it will bend or breakaway at the post/base connection at the ground line when it is hit. This improves safety and makes repairs easier.

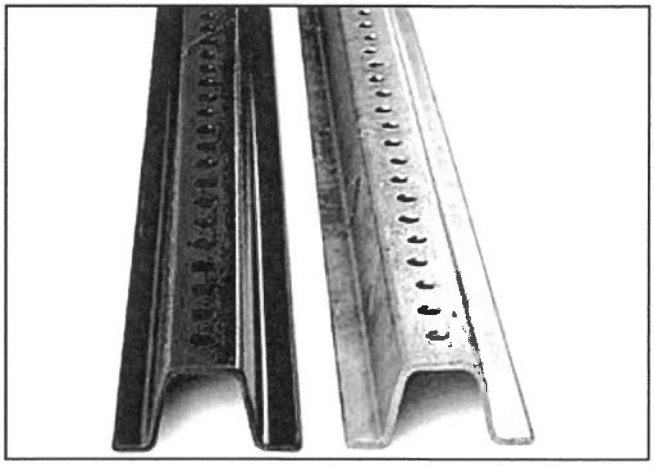


Photo of typical U-channel posts. The silver post has been galvanized.

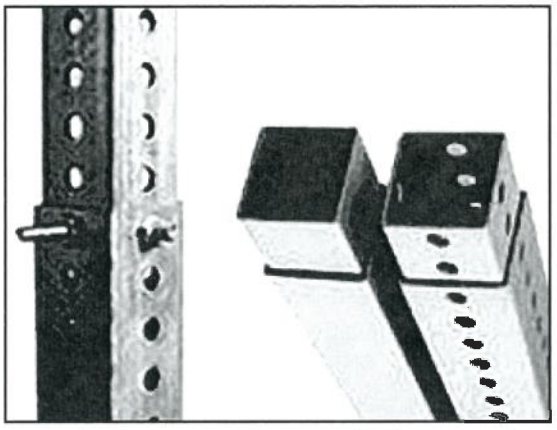
The manufacturer of U-channel steel posts must provide certification that the posts and hardware have essentially the same chemistry, mechanical properties and geometry as that used in the Federal Highway Administration tests and will meet the FHWA change in velocity requirements.

Certification must also be provided that the U-channel lap splice system will develop the full shear and bending yield strength of the sign post section being spliced.

Supports

Posts should be either the square tube post or the U-channel type. Signs mounted with the square tube posts should be installed as follows:

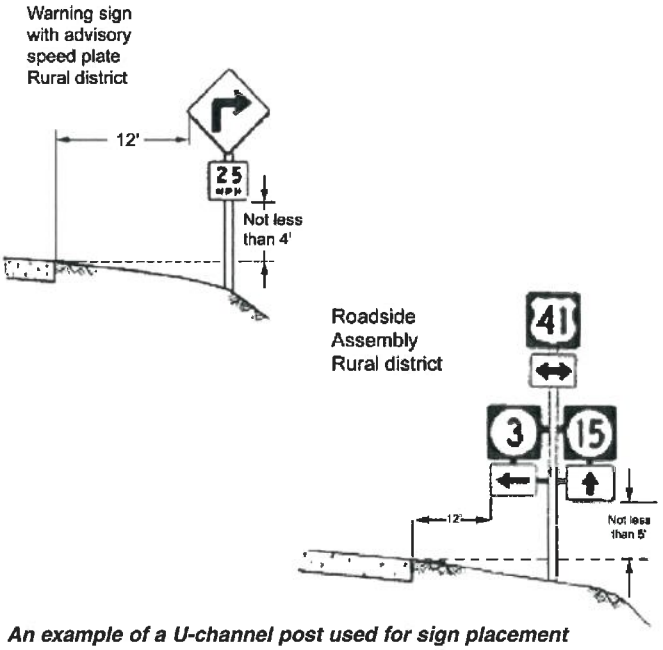
Area (square feet)	Mounting with (P-5) square tube post (inches)
Up to 7.5	Single 2¼ x 2¼ post
Over 7.5 to 15	Two 2¼ x 2¼ posts
Over 15 to 20	Two 2½ x 2½ posts



Examples of typical square tube posts which are sometimes used in proper sign installation.

Single post installations should be in accordance with NDOT specifications. Signs with two posts require a slip base and should be installed according to the manufacturer's recommendations (except that the sign post anchor should be embedded at least 4 feet below the ground surface). Signs mounted with U-channel post should be installed as follows:

Area (square feet)	Mounting with (P-5) U-Channel posts
Up to 10	Single post
Over 10 to 20	Two posts

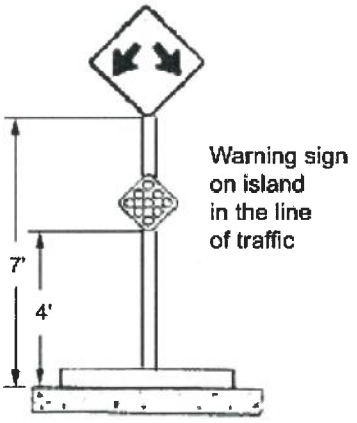


An example of a U-channel post used for sign placement and installation.

Panels

For typical installations of small signs (up to 2 square meters), use a hot-dipped galvanized button-head bolt with a slot in the head and nut with a lock washer.

There should be a minimum of 6 mm of threads beyond nuts on all signs after they are securely fastened. Signs with a width greater than or equal to 1.2 meters, or an area more than 0.75 square meters up to and including 2 square meters, require two posts.



Adapted with permission from the Baystate Roads Program Tech Note #40.

StreetWise is published periodically by the Nevada Transportation Technology Transfer Center at the University of Nevada, Reno. Phone: 775-784-1433

STOP signs are not a solution for residential speed control

Speeding on local streets is probably the most persistent problem facing residents and traffic officials alike.

Every traffic engineer has been shaken by the telephone caller who opens with, "If something isn't done about the speeders on our street someone is going to be killed and it will be your fault," followed by a demand for various traffic control measures and threats of petitions with several hundred signatures.

Although there could be a flaw in the traffic engineering plan, most often the problem is one of perception. Residents who consider speeds excessive in their own neighborhood often consider the same speeds reasonable when they drive in other neighborhoods.

A resident's complaint usually includes the solve-all solution to the speeding problem—install STOP signs.

The traffic official's common response is that STOP signs don't work to control speeding because :

a. research has shown that speeds often increase between the signs,

b. they are frequently violated,

c. they are detrimental to safety and,

d. they are not warranted in the Manual on Uniform Traffic Control Devices (MUTCD).

The STOP sign as a trophy

When residents are told that stop signs are not the answer to the speeding problem, they often feel their only option is to fight city hall to get them installed. In the confrontational relationship that results, the stop sign becomes a trophy that is awarded to the "winner." Solving the speeding problem becomes secondary to winning the trophy. The results of this process are usually unhappy citizens who continue to complain and request more stop signs and, quite often, approval for the sign installation in an attempt to tem-

Community solutions to residential speed control

A good way to eliminate confrontational relationships between residents and traffic officials and avoid knee-jerk reactions to traffic engineering is to develop a process that involves both traffic officials and affected community members.

Some communities have successfully employed a standing committee, normally referred to as the "Citizen Traffic Committee," to deal with traffic-control issues. The committee members need to educate themselves on aspects of traffic engineering, but are also advised by non-voting staff experts who provide input and send recommendations to the decision-making body.

Another option is the "ad hoc" or advisory committee. An ad hoc committee is formed when a community seeks help in dealing with a specific traffic control problem. The committee identifies the problem and sets quantifiable goals that it hopes to reach. Traffic engineering staff collects data for the identified problems, presents it to the committee, identifies options, presents alternatives, and then explains the pros and cons, costs, etc., of each option. The committee and the staff discuss the alternatives until they agree on a solution to be recommended to the decision-making body and the community at large.

Advantages of a community committee

- It hears-out neighborhood traffic control concerns.
- It may be perceived as more objective than official staff.
- It acts as a buffer between the decision-making body and citizens.
- It creates an understanding of traffic engineering principles among laypersons.
- It builds a relationship between staff and community that can be used for working through future problems.
- It dampens the adversarial relationship that often develops between the citizens and staff.

Disadvantages of a community committee

- It can consume considerable time and effort of the engineering staff.
- It might divide the neighborhood if a consensus cannot be reached.
- It can become an unwieldy process if not handled skillfully by staff.

Citizen input can be used to solve problems of all kinds—not just traffic control problems. So whenever possible, consult your community. Think of it as talking to your boss, because they are in fact your employer.

STOP signs as a speed control solution

porarily bring the controversy to an end.

What the studies show

Experience and research show that speeding problems are usually not solved by the installation of a stop sign. Before-and-after studies show that stop signs increase mid-block speeds and create violators of motorists who feel the sign is unwarranted.

When not required to stop by cross street traffic, only 5 to 20% of all drivers come to a complete stop, 40 to 60% will come to a rolling stop below 5 mph, and 20 to 40% will pass through at higher speeds. Signs placed on major and collector streets for the purpose of speed reduction are the most flagrantly violated. Stop signs placed for right-of-way assignment are more likely to be obeyed, whereas stop signs that do not meet the standard warrants tend to be ignored by drivers.

Effect on traffic volume

The basic purpose of a stop sign is to assign right-of-way at intersections. Regardless of their intended purpose, stop signs are persistently requested by citizens with the expectation that the signs will control speed or reduce traffic volume in residential neighborhoods.

Stop signs do little to reduce traffic volume when local streets offer significant avoidance of congestion points on major and collector routes. However, when a local street offers only a slight advantage over other routes, the time lost at additional stop signs may be enough to shift traffic.

Two-way stop

This is used to assign right-of-way to traffic on one of two intersecting streets by requiring traffic on one street to come to a complete stop.

A two-way stop is suitable:

1. Where one street is a major street;
2. Where sight distances approaching the intersection are substandard and traffic approaching under the general rules for uncontrolled intersections would run a strong risk of being involved in collisions;
3. Where a crash pattern exists that could be corrected by right-of-way controls, yet conditions do not require traffic on both streets to stop.

Four-way stop

Four-way stops are more common in the United States than in other countries. They are intended for use where two collector or major streets intersect and traffic volumes do not warrant a traffic signal. They have often been used in response to complaints by the public about excessive speeds, but this application has produced questionable results.

Effect on traffic speed

The general conclusion from many studies on the effectiveness of stop signs as a speed control measure is that they have little overall effect on speed, except within about 150 feet of the stop sign. They are reported to have little or no effect in controlling mean (average) or 85th percentile speeds at mid-block. (The 85th percentile speed is that speed at which 85% of the traffic is travelling at, or below.)

A stop sign observance study of unwarranted four-way stops in Troy, Michigan, found that the percentage of no-stops or roll-stops was significant after the installation of unwarranted stop signs, and there was no significant change in 85th percentile speeds.

A study in Star City, West Virginia, showed an increase in no-stops from 14.1% to 25.1% when two-way stops were converted to four-way stops each summer for pedestrian safety. The mean speed was not significantly affected by the presence of the four-way stops, and the recommendation of this particular study was to end the practice of using four-way stops for speed control.

Effect on traffic noise, air quality, and energy consumption

When stop signs cause traffic to stop, there is a noticeable noise increase in the vicinity of an intersection from acceleration and braking. Additionally, deceleration, idling, and acceleration of vehicles increases air pollutant emissions and fuel consumption.

Effect on traffic safety

Stop signs that are not warranted by traffic volume or specific site safety conditions tend to increase traffic crashes because they introduce a general disregard of stop signs. Motorists who violate unwarranted traffic controls tend to carry this behavior to intersections where traditional warrants for stop sign installation were actually met, thereby creating a dangerous situation and increasing the potential for accidents.

Uniform standards and warrants

Warrants for stop sign installations are included in the MUTCD. These warrants relate to right-of-way assignment and respond to site safety conditions. The Manual specifically states that "Stop signs should not be used for speed control." Those may be harsh words to a resident who files a complaint, but when accompanied with some explanation of the engineering principles involved and the results of studies and actual experience, it should be possible to work out a more appropriate solution.

Adapted in part from "Solving the Speedway Problem," *The Bridge*, Vol.6, No.3, Michigan's Local Technical Assistance Program; *Speed Control in Residential Areas*, Office of Highway Safety Planning, Michigan Department of State Police; and *Speed Control on Local Streets in Residential Areas*, the Michigan Traffic Engineering and Environment Coordinating Committee.

"CHILDREN AT PLAY" SIGNS DO NOT GIVE A CLEAR MESSAGE

Road signs give messages to drivers. If the messages are unclear, unnecessary, or confusing they can cause danger to motorists and others. Vermont municipalities and the Vermont Agency of Transportation use the Manual on Uniform Traffic Control Devices (MUTCD) as the standard for placing traffic signs and markings to give clear messages to motorists.

According to the report "Maintenance Management of Street and Highways Signs" by the Transportation Research Board, improvements in traffic signing have the highest benefit-cost ratio of any highway safety improvement. About 29% of tort liability lawsuits against highway departments are related to traffic signing. For these reasons alone it is worthwhile to install road signs according to the MUTCD.

Citizens often demand that the town erect Children at Play signs on their street to reduce the risk of automobile-pedestrian accidents. Selectmen ask: What does the MUTCD say about Children at Play signs? If we erect a sign on one street, won't we get requests from other neighborhoods in town to do the same? What's the town's liability?

The short answer is "Do not erect Children at Play signs". The long answer is a bit more complicated.

First, the Children at Play sign is unclear and unnecessary. It suggests to the driver that, if no such sign is present on another street, children are not playing there, and it is OK to speed or to be less careful. Another driver might interpret the sign to mean that children are playing in the road. Always? At what time of day?

Second, it gives parents and children a false sense of security. By relying on the sign, parents might monitor their children less closely and children might interpret the sign to mean it is acceptable to play in the street.

Third, one Children at Play sign leads to a proliferation of signs throughout the town. Since nearly every block has children living on it, there would have to be signs on each one. The effect of too many signs is that they become ineffective. The proliferation of signs breeds disrespect, not only for the specific signs, but for all signs.

Fourth, to erect Children at Play signs in response to one request usually generates similar requests, thereby basing sign placement on politics rather than on sound traffic engineering judgement.

Fifth, based on numerous studies, there is no evidence that Children at Play signs prevent injury or decrease the speed of vehicles.

Sixth, because they are confusing and do not meet specific criteria for good signing, placing Children at Play signs opens the municipality to tort liability.

Seventh, since all signs need to be maintained to be effective, the proliferation of unnecessary signs places an undue burden on maintenance crews. Purchasing, erecting and keeping these signs in good order is expensive.

For these reasons, the MUTCD discourages the use of Children at Play signs. However, municipalities can and should post signs for school zones, pedestrian crossings, and playgrounds. The MUTCD makes specific reference to these situations. Signing such areas gives clear messages to drivers about the kind of zone they are entering. Children at Play signs, on the other hand, do not meet a specific criteria.

Pavement Markings

Pavement markings have definite and important functions. In some cases they supplement regulations or warnings given by other devices. In other cases they are used alone and produce results that cannot be obtained by any other device.

Pavement markings have limitations. They are obliterated by snow, may not be clearly visible when wet, and may not be very durable under heavy traffic. It may be necessary to repaint them every year, or more often. Despite these limitations, pavement markings are still used because of their unique advantage: they convey information to drivers without diverting their attention from the road.

This bulletin introduces basic concepts for pavement markings. It should also help in applying the standards of the ***Manual on Uniform Traffic Control Devices (MUTCD)*** and the ***Wisconsin D.O.T. Supplement.*** The ***Traffic Control Devices Handbook*** will also help. Refer to the ***MUTCD*** for details.

Materials

Hot- and cold-applied paint are the most common materials for pavement marking. Hot paint has proven to be more effective because of its consistency under changing temperature conditions and because of its faster drying time. However, equipment used to apply hot paint is more expensive than for cold paint. Thermoplastics, epoxy, and other durable markings are used sometimes, and may be more economical in urban high traffic areas which need frequent maintenance. Whichever material you use, it should remain the correct color and reflectorized throughout its useful life. All pavement markings should be reflectorized by mixing in glass beads or dropping them on. The only exceptions are parking lines and curb markings. In pedestrian areas, marking materials should not create slipping or tripping hazards.

Colors

Pavement markings must be yellow or white. Words and symbols, crosswalk lines, stop lines, lane lines, and right edge lines on one-way roads are white. Center lines, no-passing lines, and left edge lines on all one-way paved roads, are yellow.

General principles

All pavement markings should conform to several general principles:

- Yellow lines separate traffic flowing in opposite directions or mark the left edge of the pavement on one-way roadways.
- White lines separate traffic flowing in the same direction or mark the right edge of the pavement.
- Broken lines may be crossed; solid lines should not be crossed.
- Line width indicates the degree of emphasis. Normal center lines and edge lines are four inches wide. A wide line is at least twice the width of a normal line.
- Double lines, two normal width lines separated by a discernible space, indicate maximum restrictions.
- A broken line is formed by segments and gaps, usually in the ratio of one to three. A recommended standard on rural roads is 10-foot segments followed by 30-foot gaps.

Center lines

A center line separates traffic traveling in opposite directions and is usually at the geometrical center of the pavement. Center lines give drivers important guidance and should be used on roads which have substantial traffic volume. The Wisconsin D.O.T. recommends 400 vehicles per day. In addition, center lines are recommended only on paved rural two lane roads 16 feet or more in width with prevailing speeds above 35 mph, or in residential or business districts with significant traffic volumes.

The center line markings on two-lane, two-way highways should be one of the following:

- a normal broken yellow line where passing is permitted, or
- a double line, one normal broken yellow line and one normal solid yellow line, where passing is permitted in one direction, or
- a double line of two normal solid yellow lines where passing is prohibited in both directions.

When a center line is used, all no passing zones MUST be marked.

No-Passing zones

A no-passing zone at hills and curves is warranted where the sight distance is less than the minimum necessary for safe passing at the prevailing speed. The following table lists several traffic speeds and their corresponding minimum sight distances required for passing. These must be measured and marked by a trained person.

Table 1: Traffic speeds and minimum sight distances*

Speed	Sight Distance
25-30 mph	.10 miles
35-40 mph	.13 miles
45-50 mph	.15 miles
55 mph	.21 miles

* from: *Wisconsin D.O.T. Supplement*

No-passing zones are also warranted before particularly hazardous areas such as narrow bridges, railroad crossings, and intersections.

Mark no-passing zones by a four inch wide, solid yellow line placed on the right of the center line. To mark no-passing in either direction, use two solid yellow, four inch lines separated by at least four inches.

In a rural area a no-passing zone should be at least 500 feet long. If the actual no-passing distance is less than 500 feet, add the extra marking at the beginning.

When the distance between the end of one no-passing zone and the beginning of the following no-passing zone is short, the zones should be extended through the intervening distance. Table 2 gives the minimum distances between zones at various speeds.

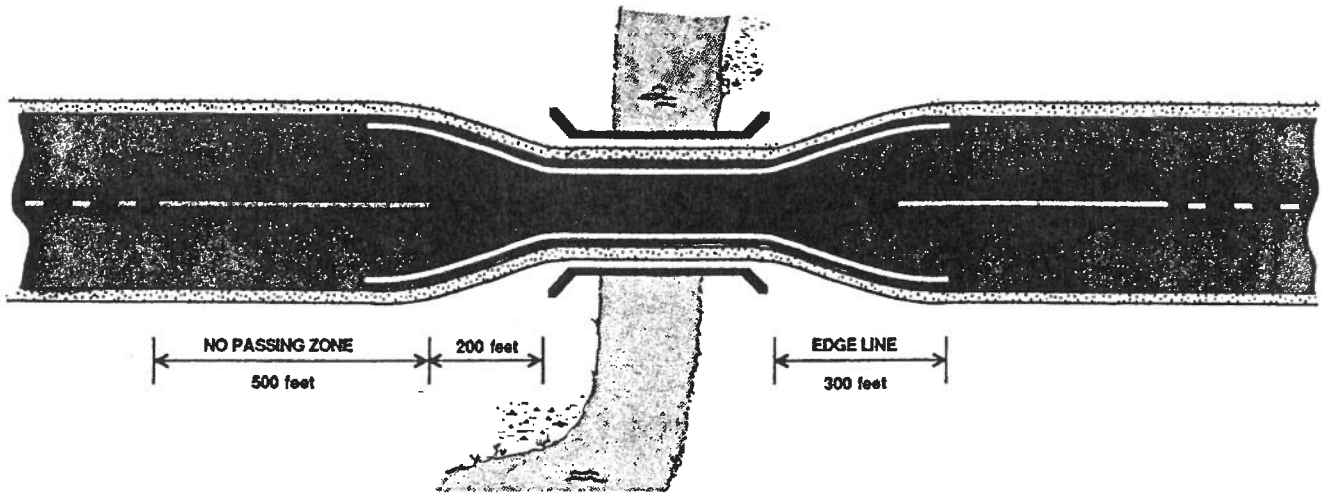
Table 2: Minimum distance between No-Passing zones*

Speed Limit	Minimum Distance
25-40 mph	.10 miles
45-50 mph	.125 miles
55 mph	.15 miles

* from: *Wisconsin D.O.T. Supplement*

A no-passing zone begins at that point at which the sight distance first shrinks below the minimum (see Table 1). The zone ends where the sight distance becomes longer than the minimum.

Pavement markings for one lane bridges (less than 18 feet in width) deserve special mention. Do not carry the centerline over the bridge. The following illustration shows one way to use pavement markings to call attention to a one lane bridge. *Warning signs are also required in accordance with the MUTCD.*



Pavement markings call attention to a one-lane bridge

Lane lines

Lane lines separate lanes of traffic in the same direction. They are usually broken white lines which permit lane changing.

Use a normal solid white line as the lane line in critical areas where you wish to discourage lane changing such as an approach to a busy intersection.

Pavement edge lines

Pavement edge line markings give drivers a guide to the edge of the pavement. They are a particularly valuable visual reference during bad weather and poor visibility. They can also be used to mark the pavement edge to reduce driving on paved or unpaved shoulders. Break edge lines for intersections, but do not break them for driveways.

Stop lines

Stop lines are solid white lines normally 12 inches to 24 inches wide. Stop lines emphasize the stop condition and indicate where to stop. They are not required, but are helpful in many situations. For example, visibility may be better at a point closer to the intersection than the stop sign can be placed. The stop line can be used to show this to drivers. Stop lines normally go four to 20 feet ahead of a marked crosswalk. They should parallel the crosswalk.

Crosswalks

On roads where traffic is not controlled by signals or stop signs, crosswalk markings warn the motorist of a pedestrian crossing point. On controlled intersections, crosswalk markings primarily guide pedestrians in the proper paths. Do not use crosswalk markings indiscriminately. Only an engineering study should recommend installing crosswalks where there are no traffic signals or stop signs.

Crosswalk lines are two parallel solid white lines normally spaced eight feet apart (six feet minimum). They are normally six inches or more wide, and may be increased to 24 inches where:

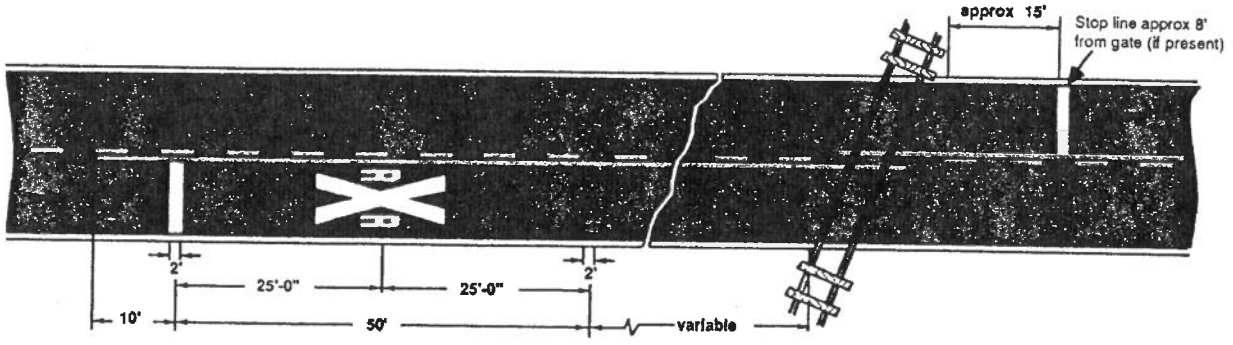
- traffic speeds are above 35 mph
- there is no advance stop line
- drivers don't expect crosswalks

For added visibility, mark the area inside the crosswalk with white lines at a 45 degree angle. These lines should be about 12 to 24 inches wide and spaced 12 to 24 inches apart. Use these diagonal lines on crosswalks at unexpected areas, where many pedestrians are crossing without any other traffic control device, and where physical conditions make added visibility desirable. Pedestrian crossing signs are also useful.

Railroad crossings

Special pavement markings are required before railroad crossings with signals or automatic gates and at all crossings where the prevailing speed of highway traffic is 40 mph or higher. Railroad crossing pavement markings may be omitted in other special situations such as where highway traffic is less than 400 vehicles per day or in urban areas where the traffic is controlled by traffic signals.

Pavement markings before a grade crossing are an "X" with an "R" on each side. A wide line is placed above and below the "X". Identical markings must be placed on each approach lane. All markings should be white and reflectorized. Stop bars must extend from the center line to the edge of the pavement, at 90 degrees to the direction of travel.



Words and symbols

Word and symbol markings may guide, warn or regulate traffic. They should not have more than three lines of information. These markings must not be used where a movement that would otherwise be legal is prohibited, unless they accompany standard signs. Repeat signs or markings in advance of their actual effect to help drivers select the appropriate lane.

All letters and symbols should conform to the standard alphabet for highway signs and pavement markings contained in ***Standard Alphabets for Highway Signs and Pavement Markings.*** (Your Wisconsin D.O.T. District office should have a copy available for you to use.) Use large letters, symbols and numerals. Messages of more than one word should read "up" (the first word is nearest the driver). For low speed roads make the space between lines at least four times the height of the character.

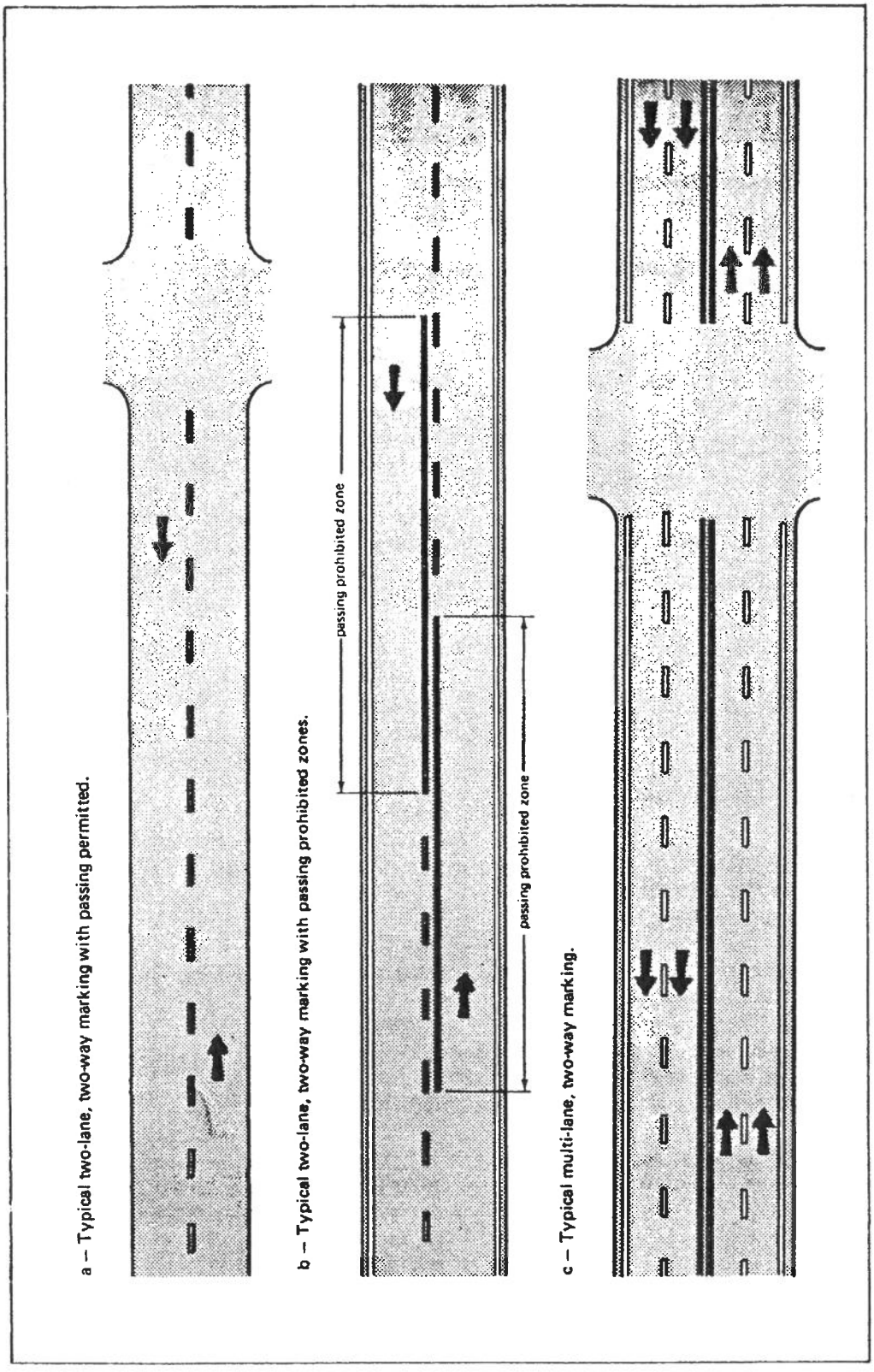
Since uncontrolled use of pavement markings can confuse drivers, minimize the number of different word and symbol markings. Symbol messages are generally preferable to word messages.

Summary

- Pavement markings are effective because they convey information without diverting attention from the road.
- They are limited by being obliterated by snow, water or traffic.
- A center line is normally used on higher volume roads (over 400 vehicles a day) or on hazardous stretches. A broken lines is formed by segments and gaps in the ratio of one to three.
- Pavement markings must be reflectorized.
- No Passing zones must be marked if a center line is used. They must be surveyed by a qualified person.
- Yellow pavement marking lines separate traffic flowing in opposite directions or mark the left edge of the pavement on one-way roadways.
- White pavement marking lines separate traffic flowing in the same direction or mark the right edge of the pavement.
- Line width indicates the degree of emphasis. Normal center lines and edge lines are four inches wide.

Wisconsin Transportation Bulletin is a series of fact sheets providing information to local town, municipal and county officials on street and highway design, construction, maintenance and management. These fact sheets are produced and distributed by the Transportation Information Center, a project of the University of Wisconsin–Madison, Department of Engineering Professional Development, funded by the Federal Highway Administration, Wisconsin Department of Transportation and UW–Extension. UW–Madison provides equal opportunities in employment and programming, including Title IX requirements.

Copies are available free while supplies last from the ***Transportation Information Center,*** UW–Madison, Department of Engineering Professional Development, 432 N. Lake Street, Madison, WI 53706. Phone 800-442-4615.



Source: Adapted from figures in MUTCD.

Figure 5-1. Typical Center Line Marking

FHWA Recommends
Ready-to-Use Safety Technologies

RETROREFLECTIVE TRAFFIC CONTROL DEVICES
A technology that facilitates safe navigation of the roadway for all drivers

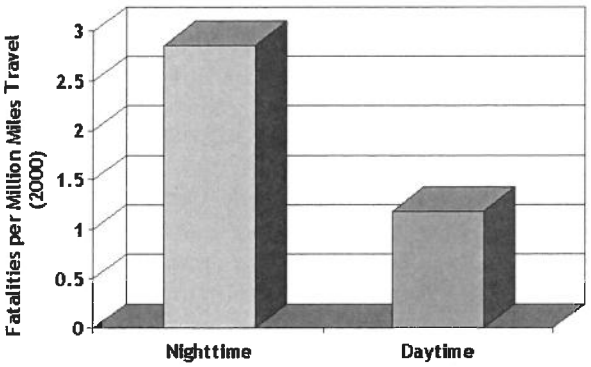
More Than Half of All Traffic Fatalities Occur At Night

While nearly a quarter of all travel occurs at night, about one-half of traffic fatalities occur during nighttime hours (including dawn and dusk hours). Out of the 42,116 fatalities that occurred in 2001, 20,648 were nighttime fatalities.

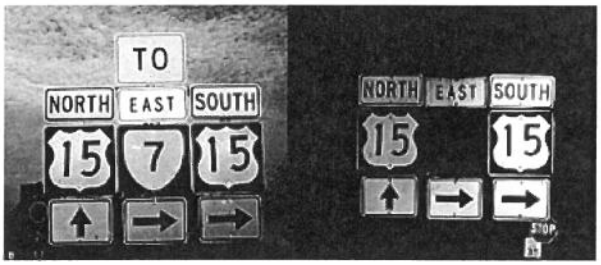
Highway statistics reveal a nighttime fatal crash rate that is more than three times the daytime rate. And there are more injuries and more property damage in nighttime crashes.

In 2001, problems with driver vision, vehicle, hardware, or environmental conditions are cited as "related factors" in some fatal crashes. Since more than half of all fatal crashes involve only a single vehicle, the final statistic may greatly underestimate the impact of vision and visibility on driving safety.

Night Travel and Fatalities



Source: National Safety Council



Why There Are So Many Nighttime Crashes

Drivers need visual cues to alert them to upcoming driving conditions. During daylight hours, drivers have many visual cues to help interpret roadway alignment such as signs, pavement markings, roadside barriers, and vegetation.

These visual cues are extremely important. They help drivers navigate the roadway by communicating the needed regulatory, warning and guidance messages to drive safely.

One reason there are so many nighttime crashes is because drivers are less able to see these visual cues – whether it be a sign, a pavement marking or some other type of traffic control device.

Nighttime Roadway Needs of An Aging Driving Population

Although older drivers are not the cause for the high nighttime fatality rate, providing nighttime visibility is becoming increasingly important as our driving population ages.

Simply put, older people have a harder time seeing. Currently, 26.2 million drivers are 65 years or older. By 2010 an estimated 33.7 million drivers will be 65 years or older. Increasing nighttime visibility is extremely important for this growing segment of drivers.

Federal Highway Administration ■ Office of Safety
400 Seventh Street SW, Washington, DC 20590
Tel.: 202-366-2288 Website: http://safety.fhwa.dot.gov

FHWA RECOMMENDS THE USE OF RETROREFLECTIVE TRAFFIC CONTROL DEVICES: A Technology That Facilitates Safe Navigation Of The Roadway For All Drivers

Why Retroreflective Traffic Control Devices Prevent Nighttime Crashes

Headlights and roadway lighting help to illuminate the roadway but often they are not enough to meet the needs of nighttime drivers.

Retroreflective materials on signs, pavement markings and other traffic control devices help offset the lack of visual cues in the nighttime driving environment because they are more visible to a driver.

This is why retroreflective control devices should be used; the sooner a driver sees a sign or a pavement marking, the sooner a driver can take appropriate actions.

What is Retroreflectivity and How Does It Work?

Retroreflectivity is a technology that uses small glass beads or prismatic reflectors to reflect light back to its source.

When retroreflective materials are used on a roadway sign, it can make a sign seem to glow at night. By reflecting the light from a vehicle's headlights back to the vehicle and to the driver's eyes, the sign appears brighter and is more visible to the motorist.

Benefits of Retroreflectivity

- Promotes greater roadway safety
- Offsets the lack of visual cues at night
- Especially helpful to older drivers – a growing segment of the population

Managing Your Retroreflective Signs and Pavement Program

Retroreflective sign sheeting and pavement marking paints will degrade over time from weather impacts and traffic use. Also, a sign's retroreflective effectiveness is lessened when the sign is bent, cracked or vandalized with paint.

So when is the best time to replace retroreflective signs and markings? Replacing them too soon will increase maintenance costs, but replacing them too late compromises safety and driving comfort. Replacing signs and pavement markings when they reach minimum levels of retroreflectivity is the best way to get the full life of signs and markings.

FHWA Retroreflectivity Levels

With input from state and local highway agencies, FHWA has developed minimum sign retroreflectivity levels and is proceeding with rule making to establish national levels.

These levels will support provisions in the Manual on Uniform Traffic Control Devices (MUTCD) to improve nighttime sign visibility on all roads, streets, and highways in the United States. They will enable highway officials to better manage their sign resources to maintain night visibility.

FHWA is also developing minimum retroreflectivity levels pavement markings.

9.1 11/19

For More Information, Contact:
Peter Hatzi, FHWA Office of Safety
Phone: 202-366-8036
Email: Peter.Hatzi@fhwa.dot.gov

Sign Inventory & Management

Better management should minimize maintenance costs; better signing should lead to increased traffic safety and decreased crash rates; and an up-to-date inventory system can reduce the agency's risk of liability when accidents do occur. It is very important to develop and maintain a sign inventory. Without a record of the type, size, location, and age of a sign, it is often difficult to know what signs are missing or where maintenance efforts can be best applied. A sign inventory can help you respond quickly and more effectively to an incident report. It can help identify areas where there are vandalism or accident problems. Small communities with less than approximately 150 signs may choose to use simple file cards to maintain information on each sign. Larger inventories of signs can be managed in a computer database. Information that should be included in the inventory and subsequent condition surveys includes:

Inventory Info	**Survey Info (to be inspected annually)**
Name of Road or Route #	Date of Survey
Direction of Travel	Sign Condition (new, good, fair, poor, missing)
Location (mileposts, intersection, etc.)	Defects (sight distance, hidden by vegetation, placed wrong, vandalism, bent, twisted, scratched, faded, none, etc)
Placement (left, right, overhead)	Visibility Distance
Height	Daytime Visibility (yes or no)
Lateral	Nighttime Visibility (Retroreflectivity level)
Sign Size (width x height)	Support Condition
Sign text and/or image	Additional Comments
MUTCD Code	
Inventory Number	
Face Material	
Substrate (Backing) Material	
Support Type (steel, wood, etc.)	
Date installed, replaced, repaired	

Adapted from excerpts from the FHWA report "Maintenance of Signs and Sign Supports for Local Roads and Streets: A Guide for Street and Highway Maintenance Personnel", FHWA-RT-00-00

Addressing Crash Hot Spots

Every community has a handful of intersections and roadway sections that have high numbers of crashes. These crash "hot spots" may be the result of careless drivers, but too often the real culprit is the design of the roadway and/or traffic control. For this reason, a systematic effort should be made to identify high crash locations, and correct deficiencies that may exist in the roadway or traffic control devices. Listed below are some common crash patterns, their probable causes, and the general countermeasures.

Crash Pattern	Probable Cause	General Countermeasure
Right-angle collisions at unsignalized intersections	Restricted sight distance	Remove sight obstructions Restrict parking near corners Install stop signs (see MUTCD) Install warning signs (see MUTCD) Install/improve street lighting Reduce speed limit on approaches** Install signals (see MUTCD) Install yield signs (see MUTCD) Channelize intersection
	Large total intersection volume	Install signals (see MUTCD) Reroute through traffic
	High approach speed	Reduce speed limit on approaches** Install rumble strips
Rear-end collisions at unsignalized intersections	Pedestrian crossing	Install/improve signing or marking of pedestrian crosswalks Relocate crosswalk
	Driver not aware of intersection	Install/improve warning signs (see MUTCD)
	Slippery surface	Overlay pavement Provide adequate drainage Groove pavement Reduce speed limit on approaches** Provide "Slippery When Wet" signs
	Large numbers of turning vehicles	Create left- or right-turn lanes Prohibit turns Increase curb radii
Rear-end collisions at signalized intersections	Poor visibility of signals	Install/improve advance warning devices Install overhead signals Install 12 in. signal lenses (see MUTCD) Install visors Install back plates Relocate signals Add additional signal heads Remove obstacles Reduce speed limit on approaches**

Crash Pattern	Probable Cause	General Countermeasure
Left-turn collisions at intersections	Large volume of left-turns	Provide left-turn signal phases Prohibit left turns Reroute left-turn traffic Channelize intersection Install Stop signs (see MUTCD) Create one-way streets Provide turning guidelines (if there is a dual left-turn lane)
	Restricted sight distance	Remove obstacles Install warning signs Reduce speed limit on approaches**
Right-turn collisions at intersections	Short turning radii	Increase curb radii
Fixed-object collisions	Objects near traveled way	Remove obstacles near roadway Install barrier curbing Install breakaway feature to light poles, signposts, etc. Protect objects with guardrail
Fixed-object collisions and/or vehicles running off roadway	Slippery pavement	Overlay existing pavement Provide adequate drainage Groove existing pavement Reduce speed limit** Provide "Slippery When Wet" signs
	Roadway design inadequate for traffic conditions	Widen lanes Relocate islands Close curb lane
	Poor delineation	Improve/install pavement markings Install roadside delineators Install advance warning signs (e.g. curves)
Night accidents	Poor visibility	Install/improve street lighting Install/improve delineation markings Install improve warning signs
*** Spot speed study should be conducted to justify speed limit reduction.*		

Adapted from the FHWA's "Manual on Identification, Analysis and Correction of High Accident Locations".